BRITISH COLLEGE OF PHYSICAL EDUCATION.

TEXT BOOK No. 1.

THE

THEORY

OF

PHYSICAL EDUCATION

IN ELEMENTARY SCHOOLS.

REVISED EDITION.

BY

THOMAS CHESTERTON,

ORGANIZING TEACHER OF PHYSICAL EXERCISES TO THE LONDON COUNTY COUNCIL.

ILLUSTRATED.

THREE SHILLINGS. (Nett.)

CHESTERTON

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Founder of the British College of Physical Education.

WITH A PREFACE BY

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Late Inspector of Military Gymnasia in Great Britain.

Late Examiner in Physical Education to the School Board for London

ILLUSTRATED.

REVISED EDITION.

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PREFACE.

By means only of a rational and scientific system of Physical Education can we hope to attain the full and harmonious development of all the physical organs and senses, for the preservation of health, the uniform increase and growth of muscular power, and the strengthening and bracing up of the whole nervous system; and only by the establishment of a ready obedience of the voluntary muscles to the mandates of the will can we acquire perfect co-ordination of movement, suppleness and flexibility of limb, an active gait and graceful carriage of the body. *Unequal* development of our mental and physical faculties is injurious; their education should therefore be *coincident*. Now, the supreme importance of Physical and Mental culture being conducted concurrently is as yet far from being recognised by the great bulk of the British Nation; and indeed one may safely affirm that it has only received any attention at all from the majority of those responsible for the training of our boys and girls within a comparatively recent period; and up to a very short time ago, the Education Department made no mention whatever of Physical Exercises in the Elementary School code, and presumably considered it a matter of but small moment, whether the children of the masses grew up with undeveloped and puny bodily powers or not.

A great move, however, in the right direction has at last been made, by the introduction into the said code of a clause by which it will, in August next, become compulsory on all Elementary School managers to make due provision for the instruction of their children in "Swedish or other drill or other suitable physical exercises"—so it is worded.

It can only, therefore, now be a question of time, and let us trust a short time, before managers of High Schools and all other Educational Establishments will be compelled to take the matter seriously in hand, and indeed we may now reasonably hope that before long parents among all classes will simply refuse to send their children to any schools where suitable provision is not made for giving the instruction in question.

The demand then for scientific Instructors is sure to greatly increase, and at all Training Colleges the Students will doubtless be called upon to qualify themselves in such a manner, as to be capable of giving instruction in this subject; and therefore the production of this book of Mr. Chesterton's on the Theory of Physical Education in Elementary Schools must be considered as most opportune, and as being undoubtedly calculated to materially facilitate the study of the science, without undue labour on the part of the student, and with much economy of time. The book is exhaustive and yet concise; it enters into every detail connected with the proper development and healthy condition of the corporeal powers; it describes in an interesting and intelligible manner the wonderful mechanism of the human body; it teaches how the due performance of all the vital processes is dependent upon the functional health and activity of all the organs; and how again these are influenced and promoted in a high degree by rational and properly directed training, by moderate exercise, wholesome food, pure air, and good sanitary surroundings generally. It emphasizes the necessity for the taking of proper rest, and deals with the question of suitable clothing; and it sums up very fairly and reasonably the advantages and disadvantages attending the employment of music and singing in connection with bodily exercises, upon which point there is much diversity of opinion among experts, and there is introduced a most interesting and valuable little article on "Singing and Declamation in relation to Physical Exercise," by C. Roberts, Esq., F.R.C.S., a gentleman well known for his intimate knowledge of the science of Physical Education, and for all he has done to advance it.

The rules laid down by Mr. Chesterton for the guidance of persons conducting a practical lesson are clear, ample, and precise, and are based throughout on sound principles and common sense, and should be most carefully read and digested by all students of this subject. Attention is very properly directed to the injurious positions into which children are so liable to fall when reading and writing, and to the serious consequences which but too frequently result from the use of unsuitable desks and seats, for alas! the provision of properly constructed desks and seats is sadly neglected in very many schools, to the great detriment of the little students. The remarks upon games are excellent and much to the point, as any book on physical education, written in our own language for the inhabitants of these islands to read, would unquestionably be incomplete did it not touch upon the subject of our out-door games, for they have ever been and always will be, a powerful factor in the formation of the British character, individual and national, and it is difficult to exaggerate their importance in this connection.

Such a manual as this has long been needed, and its want much felt, and it is without doubt a very valuable addition to the literature on physical culture already in existence, and students of the subject should greet its appearance with joy and gratitude, for it cannot fail to be of material assistance to them; and Mr. Chesterton is certainly deserving of high praise for having bestowed —as he must have done—so much time, patience, and studious labour upon its production.

GEO. M. ONSLOW,
Colonel.

Cavalry Barracks,
Canterbury.
March 23rd, 1895.

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PRELIMINARY REMARKS.

Notwithstanding the numerous works now before the public with reference to Physical Education, there appears to be something wanting as a guide to the *Theory* of the subject, particularly with reference to the Physical Education of school children.

During the past six years, the London School Board has made the physical culture of the children of the Metropolis a speciality. Training classes have been formed to enable both male and female teachers to acquire the necessary qualifications, and to impart the instruction to their pupils thoroughly and systematically. Examiners have been appointed by the Board, and approved by the Education Department, to conduct the examination of the teachers in the theory and practice of Physical Education, and to grant certificates to the successful candidates. Little difficulty appears to have been experienced in passing the *practical* test, as manuals bearing on that portion of the subject have been recognised by the Board. The *theoretical* part of the subject, however, has proved a more difficult matter with which to deal, particularly as no manual of the Theory of Physical Education, with special reference to school children, appears to have been published. In consequence of this, I have compiled this work with a view of placing in the hands of school teachers and college students a brief outline of all that is absolutely necessary for them to study in order to pass an examination in the Theory of Physical Education with reference to school children; and with a view to its adoption as a text-book, by persons desirous of obtaining the Teacher's Certificate of the British College of Physical Education (*vide* Educational Code, 1895).

In compiling this manual, I am greatly indebted to numerous works on Physical Education, particularly the "Physiology of Bodily Exercise," by Fernand Lagrange, M.D., an excellent book on the subject, and well worthy the careful perusal of anyone wishing to study the subject more deeply.

I have not scrupled to make repetitions where deemed necessary in order to impress important points, while technicalities and irrelevant matter have been studiously avoided.

To further assist in making this work as useful as possible in enabling teachers and others to pass the examination in the Theory of Physical Education, numerous questions set at various examinations in the subject during recent years are attached.

The value of this work is greatly enhanced by an article on "Singing and Declamation," in connection with Physical Education, specially written by C. Roberts, Esq., F.R.C.S.

T. CHESTERTON.

LONDON.
March, 1895.

PRELIMINARY REMARKS ON THE REVISED EDITION.

Since the issue of the first edition of this work, the British College of Physical Education, and the Gymnastic Teachers' Institute have adopted it as their Text Book for the guidance of those wishing to take the examination for the Teacher's Certificate in Physical Education. It has also been approved and adopted by the Director General of Military Education for use in all Army Schools, by twelve Training Colleges in the United Kingdom, and has also been placed on the London County Council's Requisition List.

In order to make the manual as complete as possible, I have added to the Revised Edition a short treatise on Swimming, a subject which has been taken up most enthusiastically of late by a great number of school teachers. Illustrations have also been added, as far as practicable in a book of this description, to assist in more fully explaining the text; but no attempt has been made to illustrate the physiological portion, as numerous books, amply illustrated, and bearing on this branch of the subject are easily obtainable.

There has also been added a table, accompanied by suitable anatomical figures, naming some of the chief voluntary muscles brought into action in the various movements of the body. The object here has been not to add further to the subjects necessary to pass the examinations, but only to more fully explain the chapters on Articulations, Movements, etc.

T. CHESTERTON.

LONDON,

July, 1904.

INTRODUCTION.

We understand by the terms Physical Exercises, Physical Training, Physical Culture, Calisthenics and Gymnastics, all active, voluntary exercises which are undertaken with a view to strengthen and develop the muscular system and improve the physical condition. These may vary in character according to the end in view, *e.g.*, exercises may be performed in order to develop the upper part of the body; others may have for their object the development of the lower limbs; while others may serve to produce an *all-round*, as distinct from local, development.

These active movements may be classed as follows :—

(1) Exercises in which we move our own bodies.

(2) Exercises in which an extraneous but inert body is moved.

(3) Antagonistic exercises.

The first group embraces: (*a*) gymnastics on fixed apparatus; (*b*) free movements, *i.e.*, exercises performed without the aid of any apparatus. Swimming, running, walking, leaping etc., may also be included in the same class.

The second consists of exercises with such movable apparatus as dumb-bells, bar-bells, clubs, wands etc. Rowing, football, cricket, skipping, tennis, and cycling may be added.

The third comprises wrestling, boxing, fencing etc.; also games in which opposition or resistance is offered by another person.

Another classification may be based on the manner in which the exercises are performed, whether as (*a*) individual, (*b*) co-operative, or (*c*) mass exercises.

Individual exercises are those performed by one person; in co-operative exercises, two or more take part in their accomplishment; while in mass exercises a number of persons execute the same, or different movements, yet working together and observing the same rhythm.

Physical Exercises are often classed on other principles, *e.g.*, upon the muscles called into action by each exercise; but when we consider that there are but few movements of the body in which one muscle only is concerned, this system of classification is hardly feasible. Even if it could be carried out successfully it would be useless for all practical purposes. For educational purposes, the best way is to confine the classification chiefly to the actions of the various groups of muscles which are brought most frequently and prominently into play in moving the various joints and articulations in the body.

This classification is especially applicable to those exercises which quicken the circulation of the blood, increase the breathing capacity, promote nutrition, and facilitate the elimination of waste products from the system.

In physical education, the term *system* may be defined as a scientific combination of exercises based on an anatomical and physiological knowledge of the human body, the classification of the movements, and their practical application.

A *method* is the application of the exercises with regard to their suitability to age, sex, bodily condition, health, habits, and facilities which exist to aid in their execution.

THE THEORY
OF
PHYSICAL EDUCATION.

HUMAN SKELETON AND BONE.

HUMAN SKELETON: The human skeleton constitutes by weight about one-sixth of the entire body, and consists, during youth, of upwards of two hundred distinct bones; but some of them subsequently unite in the adult, thus reducing the number to two hundred. The *spine* is a flexible column consisting of thirty-three bones, the first twenty-four being separate from each other and known as the *vertebræ*; the remaining nine in adult life are united, into 2 masses forming ~~one bone,~~ called the *sacrum*. Each vertebra articulates, by its body and articular processes, with the vertebræ adjacent. The seven bones forming the neck are called *cervical*, the next twelve *dorsal*, and the last five the *lumbar* vertebræ. A substance called the *inter-vertebral fibro-cartilage*, which is highly elastic in the middle, tough and fibrous at the circumference, is interposed between the bodies of the vertebræ. Each cartilage, of which there are twenty-three, is united firmly to the bone above

and below it, and allows of some play between the vertebræ, the total play permitting a considerable amount of motion to the spine. These intervertebral substances not only play an important part in counteracting the effects of shocks and sudden concussions, but are the chief cause, owing to their wedge-shape in various localities, of the antero-posterior curves of the spine. The intervertebral substances amount to about a fourth of the movable part of the column. These substances are thicker between the lumbar and cervical than between the upper, middle, and dorsal vertebræ. The thinnest piece is situated between the second and third cervical vertebræ, and the thickest between the fifth lumbar and the sacrum.

The middle portion of each intervertebral disc is highly elastic, being composed of a pulpy semi-fluid mass which is placed nearer the rear than to the front of the disc, nearly filling the central cavity, and acting as a cushion whereby uniform pressure is secured for each vertebra. Each pulpy cushion acts as a pivot supporting the central portion of each vertebral body, and on it the movement of each vertebra take place. This semi-fluid substance is especially noticeable in the cervical and lumbar regions, and it is in those parts where the movements of the spinal column are most free.

The intervertebral substances yield to the constant vertical pressure during the maintenance of the erect position, so that a person's stature may be reduced to the extent of half-an-inch during the day, though this is regained after a few hours' rest in the recumbent position.

Each vertebra presents in front a segment of a pillar, which rests on the pelvis below, and supports the weight of the body; and a segment

of a hollow cylinder behind, which lies parallel to the pillar, and contains the spinal cord extending from the brain to the loins.

The spinal column gradually increases in size from above downwards. It is not straight, but forms a series of alternate curves. When a person stands erect with the weight of the body equally distributed between the feet, the antero-posterior curves of the spine are three in number. In the neck it has a slight convexity forwards; in the back it forms a rather long and bold curve backwards; in the loins it is again slightly curved forwards, while below it is once more bent backwards.

Upon the summit of the spinal column is the *cranium*, containing the *brain*. The first bone of the spine, called the *atlas*, articulating with both the skull and the second bone of the spine, named the *axis*, confers upon the skull great freedom of movement.

The *thorax* or chest is a kind of osseous cage bounded laterally by twenty-four ribs, twelve being placed on each side. The ribs are attached behind to the dorsal vertebræ. Most of them are connected by cartilage with the *sternum* or breast-bone, which is, viewed as a whole, a wide, flat bone, slightly convex in front, and concave behind, forming a sort of shield to the organs contained in the chest.

The first seven ribs on either side are denominated *true*, because their cartilages are joined directly to the sternum. The last five are termed *false*. The cartilages of the first three of these do not reach the sternum, but terminate in the cartilage of the last true rib; while the remaining two, having no connection with the breast-bone, are termed *free* or floating ribs.

The ribs increase in length from the first to the seventh, and diminish from the eighth to the twelfth. This increase is most noticeable in the five or six upper ribs. The first pair is nearly horizontal, while the others become successively more inclined downwards and forwards. The curvatures of the ribs become segments of circles increasing from the first downwards.

Each shoulder consists of two bones, the *scapula* or blade-bone, and the *clavicle* or collar-bone. The scapula is a large, flat, thin bone of triangular form, lying on the posterior and lateral wall of the thorax between the fifth and seventh ribs.

The clavicle is situated horizontally at the upper and lateral part of the thorax, immediately above the first rib, which it crosses obliquely. It rests internally against the upper border of the sternum, and it articulates at its outer extremity with the scapula. The clavicle and scapula form the shoulder-girdle to which is attached the bone of the upper arm.

The upper arm is formed by a single bone, the *humerus,* which is attached to the shoulder above, and supports the fore-arm below. It is the longest, largest, and strongest bone of the arm.

The fore-arm extends from the elbow to the wrist, and is formed by two bones, the *radius* and the *ulna,* the former carrying the hand, while the latter assists in forming the elbow-joint. The radius is a slightly curved bone situated at the outer part of the fore-arm, and parallel with the ulna. The ulna is situated at the inner side of the fore-arm, and exceeds the radius in length, bulk, and strength. It tapers gradually from above downwards, while the radius diminishes from its lower towards its upper extremity.

The hand contains twenty-seven bones united by thirty-two articulations. It is the smallest and most complex division of the upper extremity. It is divided into three portions, viz.:—the *carpus* or wrist containing eight bones, the *metacarpus* or palm consisting of five bones, and the *phalanges* or finger-bones, which number fourteen.

The *pelvis*, or haunch-bone, is an irregularly-shaped girdle attached to the lower end of the spinal column which it supports, and resting below on the thigh bones, to which it transmits the weight of the trunk. The haunch bears the same relation to the leg as the shoulder does to the arm. The *sacrum* is the means of attachment of the spinal column to the pelvis, and consists of a large pyramidal bone inserted like a wedge into the posterior part of the pelvis.

The haunch-bone presents near the middle of its outer aspect a large cup-like socket for articulation with the head of the thigh-bone.

The thigh is formed by a single bone called the *femur*, which transmits the entire weight of the body from the haunch to the legs. This bone is the largest, heaviest, and strongest of the whole skeleton.

The leg is formed by three bones, viz.:—two long ones called the *tibia* and *fibula* (respectively analogous to the ulna and radius of the upper extremity) and a small appendage named the *patella* or knee-cap, a small flat bone of triangular form which serves to protect the knee-joint. This is the largest joint in the body, and is formed by the articulation of the femur with the tibia.

The *tibia* occupies the anterior and internal part of the leg, extending in a direct line from the thigh to the foot. It is the largest bone of the leg, and, excepting only the femur, of the entire skeleton.

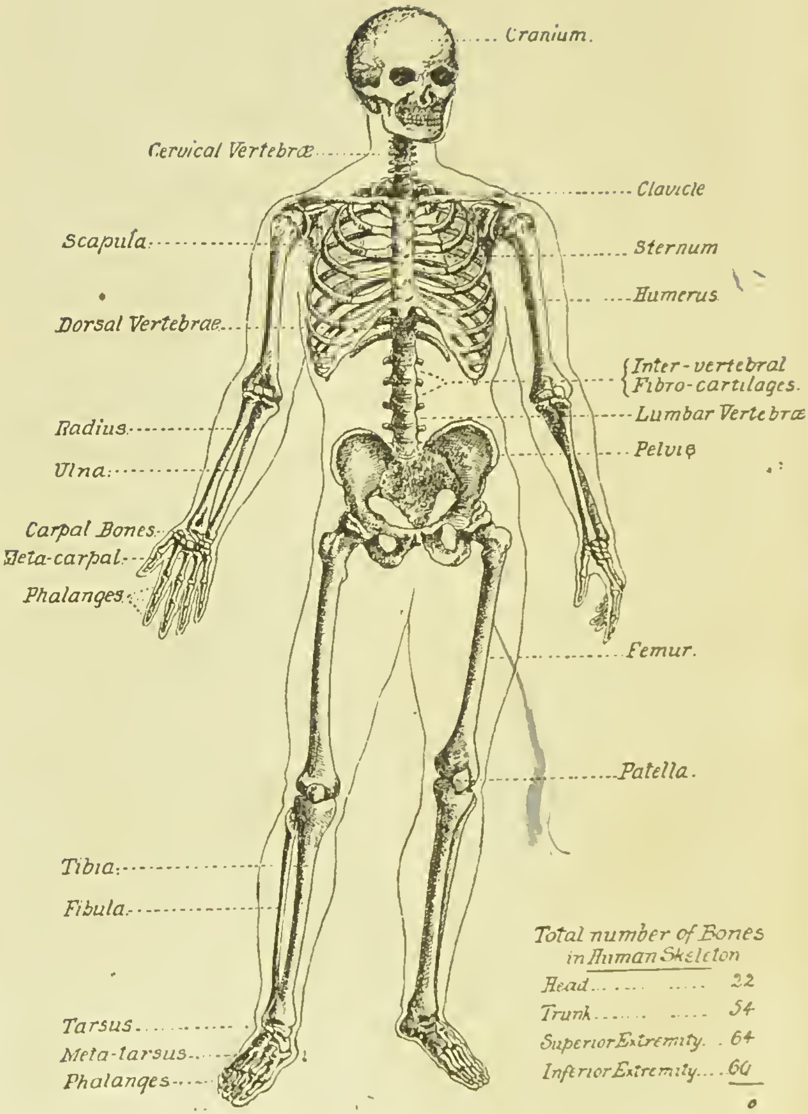

Cranium.
Cervical Vertebræ
Clavicle
Scapula
Sternum
Humerus
Dorsal Vertebrae
Inter-vertebral
Fibro-cartilages.
Radius
Lumbar Vertebræ
Pelvis
Ulna
Carpal Bones
Meta-carpal
Phalanges
Femur.
Patella.
Tibia
Fibula
Total number of Bones
in Human Skeleton
Head 22
Trunk 54
Superior Extremity 64
Inferior Extremity 60
Tarsus
Meta-tarsus
Phalanges

Fig. 1.

HUMAN SKELETON. (Fig. 1.)

HEAD.

- CRANIUM—8 bones
  - *Frontal—(forehead).*
  - *Occipital—(base of skull).*
  - *2 parietal—(sides behind frontal).*
  - *2 temporal—(contain ear canals).*
  - *Ethmoid—(in upper nose).*
  - *Sphenoid—(in front of occipital at base inside).*
- FACE—14 bones
  - *2 superior maxillaries—(upper jaw).*
  - *2 nasal—(sides of nose).*
  - *2 lachrymal—(orbits of face).*
  - *2 turbinal—(bridge of nose).*
  - *2 palate—(roof of mouth).*
  - *2 malar—(cheek).*
  - *1 vomer—(between turbinals in nose).*
  - *1 inferior maxillary—(lower jaw).*

TRUNK.

- THORAX
  - *Sternum—(chest bone).*
  - *24 ribs*
    - *14 true—upper, 7 on each side.*
    - *10 false—lower, 5 on each side, 11th and 12th pairs="floating" ribs.*
- VERTEBRAL COLUMN
  - *24 vertebræ*
    - *7 cervical — (neck), 1st bone atlas, 2nd axis.*
    - *12 dorsal—(back).*
    - *5 lumbar—(loin).*
- PELVIS
  - *2 innominate in adult. In infancy, 6 bones.*
  - *Sacrum, next below lumbar, 5 ossified into one.*
  - *Coccyx-4, end of back-bone, last bone, 'os coccyx.*

SUPERIOR EXTREMITIES.

- SHOULDER
  - *Clavicle—(above first rib).*
  - *Scapula—(behind ribs, 2nd to 7th).*
- ARM
  - *Humerus—(upper arm).*
- FORE-ARM
  - *Radius—(carries the hand and turns it over)*
  - *Ulna—(forms elbow-joint).*
- HAND—27 bones
  - *Carpal—8 bones—(wrist).*
  - *Metacarpal—5 bones—(back of hand).*
  - *Phalanges—14 bones—(fingers).*

INFERIOR EXTREMITIES.

- THIGH
  - *Femur—(upper leg).*
- KNEE-CAP
  - *Patella.*
- LEG
  - *Tibia—(shin bone).*
  - *Fibula—(splint bone).*
- FOOT—26 bones
  - *Tarsus—7 bones—(ankle).*
  - *Metatarsus—5 bones—(instep).*
  - *Phalanges—14 bones—(toes).*

The *fibula* is a long, slender bone situated on the outer side of the leg, nearly parallel to the tibia.

The foot is composed of twenty-six bones united by thirty-two articulations, and arranged in three divisions, viz., the *tarsus* which consists of seven bones, the *metatarsus* consisting of five bones, and the *phalanges* or toe-bones numbering fourteen. These divisions correspond to the three parts of the hand, and like them are distinguished by well-marked peculiarities of size, form, and structure.—(FIG. 1.)

BONE: The chief uses of bones are to protect delicate organs, and to form a framework for the body, by which, in combination with the muscles, the body is moved.

When bones are treated chemically, they are found to consist of (*a*) animal or organic matter, which yields gelatine on boiling, and (*b*) a mineral or inorganic compound, composed chiefly of phosphate and carbonate of lime. One-third of a bone may roughly be said to consist of organic, and two-thirds of inorganic, matter. The former gives to bone a certain flexibility and toughness, as may be shown by soaking it in acetic acid, so dissolving its lime, salts, etc. The latter imparts hardness to the bone, investing it with a certain amount of strength and stability. When bone is burned in a retort, the residue or ash is seen to be of a distinctly limy nature.

Anatomically considered, bones may be divided, according to the kinds of tissue they possess, into (*a*) cancellous or spongy, and (*b*) compact or dense. The relative quantities and disposition of these tissues vary in different bones, and in different parts of the same bone, according as the chief requirement is lightness or strength. The shafts of the long bones are hollow, somewhat cylindrical in form, and coated

on the exterior with a dense compact tissue; while the short bones, and the enlarged ends of the long ones, are more cellular in structure, having only a thin outer coat of compact tissue. The flat and irregularly-shaped bones possess two layers of compact tissue, with a layer of cellular structure between them. Bones have connected to them, on their outer surfaces, a dense, fibrous tissue; and beneath this is one more delicate and vascular—the *periosteum.* The cellular and compact tissues of bones are supplied with nerves and blood-vessels.

The shapes which bones assume give a ready classification into long, short, flat, and irregular bones. The long bones act as levers, as in the limbs; while the short, or cuboid, bones occur where many joints or points for motion are found, as in the spine, or when force is required over slanting surfaces, as in the carpal and tarsal bones. Flat bones are found surrounding certain cavities, as in the cranium and pelvis. There are other bones which show length as well as flatness, and have an extension of most noticeable character, as in the sternum and its connections, the ribs, and also in the inferior maxillary.

Bones have their origin in cartilage, which in shape is a model of that subsequently assumed by the bones. Ossification takes place in the following way. The cartilage loses its transparency and becomes opaque. Small bony prominences appear in the substance of the cartilage, from which, as centres of ossification, fibres radiate and gradually extend towards its circumference, so that in process of time the original characteristics of the cartilage are altered, and a spongy, vascular matter is formed.

Gradually this vascular matter diminishes, giving way to the denser, compact tissue of true bone. During this process, bones not only increase in length but also in thickness. Increase in length, in the case of long bones, is due to the deposition of inorganic matter at the parts between the ossifying centres in the shaft and those at the extremities. Increase in thickness, in the case of flat bones (which have their origin in membrane) and in that of long bones, is produced by the growth of bony layers beneath the periosteum.

The ossification of the bones commences in the middle, radiating from this, as a centre, towards the upper and lower ends. The shaft of a bone is known as the *diaphysis*, while the pieces added to the ends during growth are known as the *epiphyses*. The latter are composed of soft, cartilaginous tissue, and are connected to the bones by a soft gelatinous substance. They remain for variable periods of time in the model of the bone, till separate centres of bony growth appear in them, when they become gradually incorporated with the shaft of the bone as processes, or bony projections. These various additions are usually formed from the fourteenth to the twentieth year, and in many cases are not permanently attached to the adjacent bones till the twenty-fifth year, and sometimes even till a later age.

While bones are in a state of growth, this soft substance appears, and indicates an immature condition, denoting that the bones are not sufficiently developed to . undergo very prolonged exertion, or to sustain the fatigue of hard work.

ARTICULATIONS.

The surfaces by which bones unite are called articular; and the place of junction, or joint, between any two bones with its accompanying ligaments, cartilages etc., is called an articulation.

The joints which are formed between the bones are divided into two classes, termed *immovable* and *movable.* The immovable joints are found in the skull, the bones of which are firmly locked together by saw-like joints called *sutures.*

In some movable joints the movement is extremely limited, two more or less flattened surfaces moving slightly on each other. In this case, of which the wrist and ankle are examples, although the movement in any one joint is very slight, yet when several such joints are in close proximity, the total amount of motion is considerable. In other cases of movable joints the movements are very free, as in the hinge-joints of the fingers and toes, where a to-and-fro movement is permitted, but still through a wide range. The elbow and knee are also examples of this class of joint. The most complete and perfect type of joint, which admits of the greatest variety of movement, is the ball and socket joint, found at the shoulders and hips, and forming (with that of the thumb) the most movable in the body.

The articulating surfaces of bones are capped with a smooth surface composed of a highly polished layer of cartilage or gristle. The ends of the bones are strongly bound together by ligaments, and are more or less supported by muscles. To enable the articulating surfaces to

move freely on each other they are lined with a delicate membrane, secreting a lubricating fluid called *synovia,* which permits easy movement with the least amount of friction. Joints so provided are termed *perfect* joints, all others being *imperfect.*

In the case of the spinal column no actual joints exist between the numerous bones which compose it.

The head can be moved forwards and backwards, from side to side, and rotated. These movements are respectively termed *flexion, extension, lateral inclination* and *rotation.* Nodding takes place in the joints between the atlas and the occipital bone or base of the skull. When the head is bowed more freely the movement of the cervical vertebræ comes into play. Approximation of the head to the shoulder is chiefly effected by the lateral neck movement. Rotation is permitted by the joints between the atlas and the second cervical vertebra, called the axis. The axis is fixed, and the atlas, bound to it by the transverse ligament, moves to the right and left, carrying the head. Only a part of the whole rotatory movement is performed by the atlas and axis, the rest being due to the neck.

The movements of the scapula, though limited, are of three kinds, viz., *to-and-fro,* as when the shoulders are carried forward in contracting the chest, and backward when expanding it; *up-and-down,* as in elevating or shrugging the shoulders; and *rotary,* as instanced when abduction of the arm is carried beyond the horizontal line.

The clavicle has a limited *up-and-down* movement and a *forward-and-backward* one at its inner end, where it articulates with the head of the sternum.

In the shoulder-joint there is the common motion in four directions, together with *rotation* and *circumduction.* Carrying the humerus forward constitutes *flexion,* and moving it backwards *extension.* Flexion is less limited than extension. When the limb is raised sideways it is *abducted,* and when depressed it is *adducted.* There are two kinds of rotary movement, viz., inwards and outwards, or forwards and backwards. In *circumduction* the humerus passes in succession through the four different states above mentioned, and describes a cone whose base is at the finger points, and its apex at the shoulder.

The elbow-joint permits of flexion and extension only. In *flexion* the bones of the fore-arm are moved forwards; in *extension* they are moved backwards. Directing the palm of the hand to the ground is called *pronation,* and directing it upwards is named *supination.* These two movements are performed by one bone of the fore-arm, the radius, rotating on the other, the ulna. The radius articulates with the carpal bones and forms the wrist-joint; the ulna forms the elbow-joint by articulating with the humerus.

The wrist-joint possesses motion in four different directions, and also *circumduction.* In *flexion* the hand is moved forwards and inwards. In *extension* it is carried backwards and outwards. The movement backwards is freer than that forwards. In *abduction* and *adduction* the movement is freer towards the ulna than to the radial side. In circumduction the hand describes a cone whose apex is at the wrist, and its base at the finger-points. The thumb-joint possesses angular movement in opposite directions, with opposition and circumduction,

while the fingers have motion in four opposite directions, and circumduction.

The spinal column can be bent forwards, backwards, to either side, and rotated. In *flexion* the vertebræ between the axis and sacrum are bowed forwards. The greatest movement takes place between the last two lumbar vertebræ and the sacrum, and the least in the upper half of the dorsal region, where the ribs are united directly with the sternum. The bodies of the bones are brought nearer together in front, whilst they are separated behind. In *extension* the vertebræ are arched backwards, but not to so great a degree as when the spine is bent forwards. The motion is greatest in the neck, and is least in the dorsal vertebræ, which are fixed by the true ribs and the sternum. The posterior parts of the vertebræ are approximated, whilst the anterior are separated.

In *lateral inclination* the spine is curved to the right or to the left side. As in extension and flexion, the movement is least in the more fixed upper dorsal vertebræ, and is greatest in the neck. On the concave side of the curve the vertebræ are brought nearer together, and are carried away from each other on the opposite side.

In *rotation* the bodies of the vertebræ are twisted around a line through their central axes. The degree of rotation is greatest in the cervical and the upper dorsal region, but is almost absent in the lumbar part of the column. The general amount of rotation in the trunk is between 30° and 40° to either side. Occasionally persons are met who can only turn 25° each way.

Instances of rotating to the extent of 60° to either side have been noted in the case of persons used to a very active life, such as acrobats, etc.

The hip-joint is capable of performing the same kinds of movement as the shoulder-joint viz., *flexion* and *extension* (or to-and-fro movement), *abduction*, *adduction*, *rotation* and *circumduction*. In circumduction, the four kinds of angular motion above noticed take place in succession; but all movements are less free than in the shoulder-joint. There are two kinds of rotation, *inwards* and *outwards*.

In the former, the great toe is turned inwards; and in the latter, the more extensive of the two, it is moved outwards.

The usual movements of the knee are two in number, *flexion* and *extension*, as in the elbow; but there is in addition a slight rotation of the leg when the joint is half bent.

The movements of *flexion* and *extension* are permitted in the ankle. In the former state the toes are raised towards the fore-part of the leg, and in the latter they are pointed towards the ground. When the joint is half extended, a slight movement of the foot inwards and outwards may be obtained, but it is prevented if the foot is forcibly extended.

The movements of the toes are of a similar kind to those of the fingers, but, with one exception, more limited in range. The excepted movement is that of extension, which can be carried a little further in the toes than in the fingers. FIGS. 2 to 35.

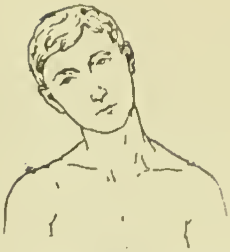
FIG. 2.

Flexion of the Head.

FIG. 3.

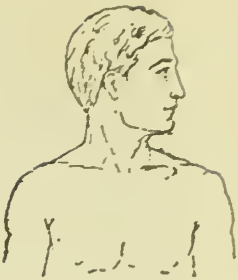
Extension of the Head.

FIG. 4.



Lateral Inclination of the Head.

FIG. 5.

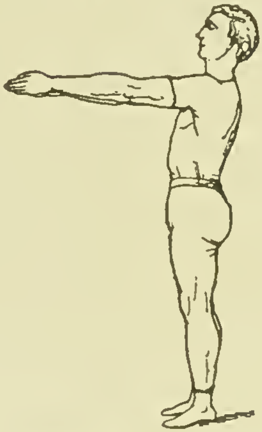


Rotation of the Head.

FIG. 6.

Elevation of the Shoulders.

FIG. 7.

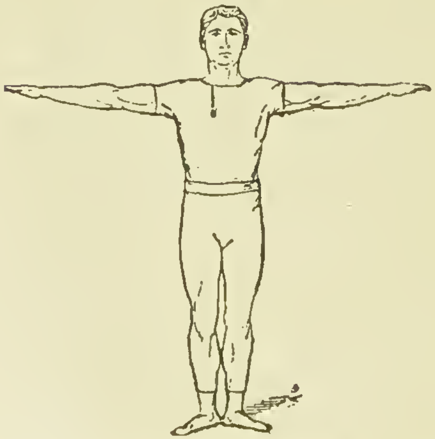


Flexion of the Arms.

FIG. 8.

Extension of the Arms.

FIG. 9.

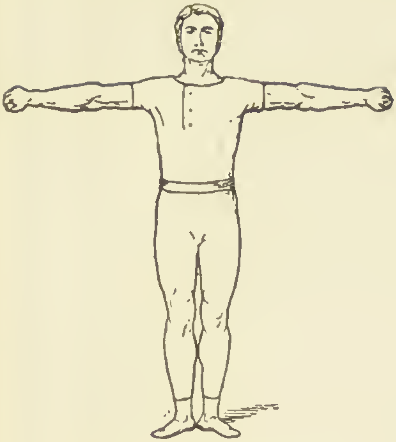


Abduction of the Arms.

FIG. 10.

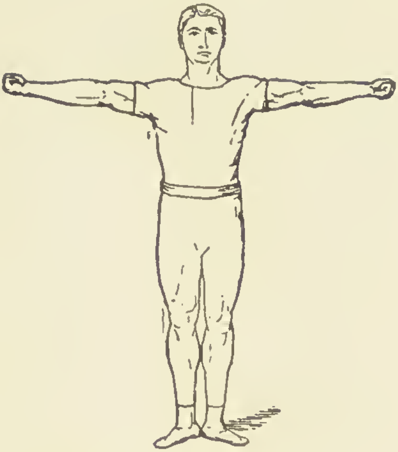
Adduction of the Arms.

FIG. 11.



Rotation Inwards of the Arms.

FIG. 12.

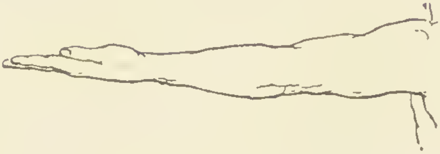


Rotation Outwards of the Arms.

FIG. 13.

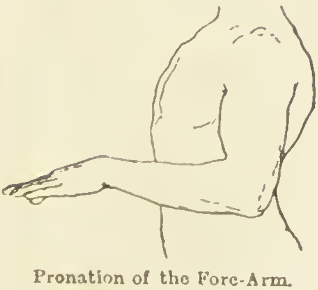
Flexion of the Fore-Arm.

FIG. 14.



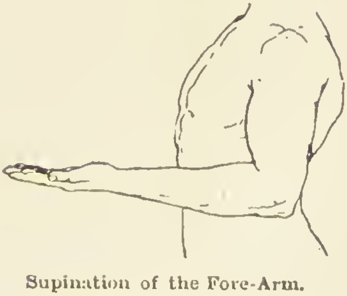
Extension of the Fore-Arm.

FIG. 15.



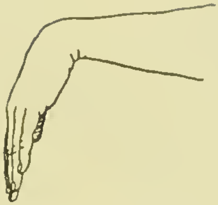
Pronation of the Fore-Arm.

FIG. 16.



Supination of the Fore-Arm.

Fig. 17.



Flexion of the Hand.

Fig. 18.

Extension of the Hand.

Fig. 19.

Adduction of the Hand.

Fig. 20.

Flexion of the Fingers.

Fig. 21.

Extension of the Fingers.

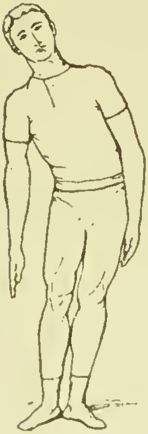
Fig. 22.

Flexion of the Trunk.

Fig. 23.

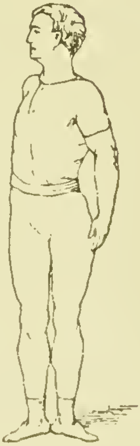
Extension of the Trunk.

Fig. 24.



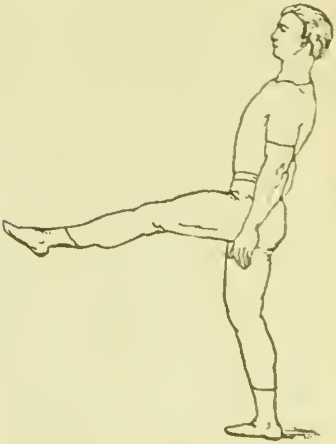
Lateral Inclination of the Trunk.

Fig. 25.



Rotation of the Trunk.

Fig. 26.



Flexion of the Thigh.

FIG. 27.

Extension of the Thigh.

FIG. 28.

Abduction of the Thigh.

FIG. 29.

Adduction of the Thigh.

FIG. 30.

Rotation Inwards of the Thigh.

FIG. 31.

Rotation Outwards of the Thigh.

FIG. 32.

Flexion of the Leg.

FIG. 33.

Extension of the Leg.

FIG. 34.

Flexion of the Foot.

FIG. 35.

Extension of tho Foot.

MUSCLE AND NERVES.

MUSCLE: A single muscle is a vast aggregation of contractile cells, arranged in linear series called *fibres*, which in turn are gathered into bundles, termed *fasciculi*. The arteries and veins usually lie side by side in these bundles of fibres, while the capillaries form a mesh-work lying between and upon them. These muscle fibres are spindle-shaped, varying from $\frac{1}{600}$ to $\frac{1}{100}$ of an inch in diameter, and are seldom more than $1\frac{1}{2}$ inches in length. The walls of the capillaries are permeable to lymph—as the nutrient portion of the blood is called—so that the muscle fibres are enabled to derive their nutriment from the lymph by which they are surrounded. The muscle fibres, fasciculi, nerve fibres, and nutrient blood-vessels are supported and bound together by elastic connective tissue, so that each muscle has its special sheath, and is attached by inelastic tendons to the parts which are approximated through its action.

The more fixed extremity of a muscle is called its *origin*, and the more movable its *insertion*. Generally speaking the origin of a muscle is that part situated nearest to the central axis of the body

Most frequently the extremity of the origin and insertion is connected with a bone. In some instances muscles have tendons of origin as well as tendons of insertion, but these are merely cords which transmit force from one point to another.

In muscular movement the origin and insertion of muscles become more or less approximated, the insertion being brought nearer to the origin.

Muscles form by weight nearly one-half of the human body, and are red in colour owing to the blood contained in them. The characteristic of muscular fibre is its power of contracting on the application of a stimulus, and relaxing when the stimulus is withdrawn.

When a muscle contracts, it produces motion by moving the bones to which it is attached. When a muscle thus acts its total bulk is in no way altered, for what is lost in length is gained in thickness. It not only swells but it becomes firmer, and during its greatest degree of contraction its length is diminished to about one-half.

All living muscle is constantly in a certain state of tension; consequently it is able almost instantaneously to respond to any stimulus that may be transmitted to it, promptness of action being the result.

There are 527 muscles in the human body, 522 being in pairs and 5 single on the median line. There are 83 in the head and face, 49 in the neck, 78 in the thorax, 33 in the abdomen, 78 in the back, 98 in the upper extremities, and 108 in the lower.

The muscles may be divided into two classes, viz., *long* and *short*. The former generally pass over one or more joints, while the latter do not pass over joints. The short muscles are employed as motors, while the long ones, as a rule, act as governors to the joints over which they pass, and regulate movement.

Muscles are also classed as *voluntary* and *involuntary*. The former are those which are under the control of the will, and are found chiefly in the head, neck, trunk-walls, and extremities. These muscles generally correspond on

each side of the body, and are in most instances composed of a *belly* and a *tendon* at each extremity. The latter are found chiefly in the thorax and abdomen, as in the heart, stomach, intestines etc. They are not symmetrical, and are generally pale yellow in colour, except the heart, which is pale reddish. These do not possess tendons in the true sense of the word, and are independent of the will. Such muscles as the diaphragm, sphincters etc., are partly under the influence of the will, but yet frequently act independently of it.

The muscles which are employed in respiration may be considered as being both voluntary and involuntary. During sleep, or when the body is perfectly tranquil, the respiratory movements are quite involuntary; but during the waking hours, whenever the number or duration of either the inspirations or expirations is altered, these changes are either involuntary, or may be brought about in obedience to the will.

NERVES: The whole of the functions carried on in the different parts of the body are regulated by the nervous system, which comprises the *brain* and *spinal cord.* From these two organs numerous nerve fibres take their origin. Each nerve fibre is a minute, semi-transparent, hollow filament, having in the living animal the appearance of white or cream-coloured threads.

The terminal portion of a nerve fibre spreads out underneath the sheath of connective tissue which surrounds a muscle fibre, and ramifies in fine fibrils through the contractile cell substance.

The central strand, or *axis-cylinder*, of a nerve fibre enters the muscle fibre or cell by passing through the single opening in the muscle sheath at its central end, and terminates

in an enlargement called the *motor end-plate* or disc. To this disc is connected the sheath which surrounds each ultimate muscle fibre, so that the disc is a means whereby both nerve and muscle are most intimately connected. Thus the contractile substance of the muscle cell is connected with the irritable generating substance of the central nerve cell, the axis cylinder of the motor nerve being the connecting link.

Running down the small canal of the vertebral column is the *spinal cord*, from which spring the roots of the spinal *motor* and *sensory* nerves, and which is a continuation of the brain. Two kinds of structure enter into its composition, viz., a *white* matter forming the external layer, and a *grey* composing the internal mass. These structures have respectively somewhat different functions. The white matter possesses the same principles of structure as ordinary nerves, but having sensory as well as motor fibres it is spoken of as possessing a *mixed* function. Each of the thirty-one pairs of nerves issuing from the cord has two roots, the posterior one being sensory, and the anterior motor in function. They are also called respectively *afferent* and *efferent* nerves, the former carrying the impression inwards, the latter the stimulus outwards.

The grey matter, in addition to its own fibres, has nerve cells, which enable the spinal cord not only to pass a motor impulse outwards, but also to generate movements in the muscles affected. In many muscular movements this process becomes a habit, for a person may be occupied mentally about other matters, and still pursue the movements irrespective of the power of volition. It appears to be the special

province of the spinal cord to govern such bodily actions when the brain may be otherwise employed.

The brain is a somewhat convex, soft mass with many convolutions of grey matter upon its surface. It differs from the spinal cord, as it has its white matter inside and its grey outside; but nevertheless it possesses nerve fibres, and its grey matter contains nerve cells also. As in the spinal cord, its white matter is sensory and the grey matter motor. The latter is also able to assert itself by the production of the so-called *reflex actions.* Still the brain has a higher function than that of the spinal cord, for it is the seat of the will and of the powers of voluntary movement.

In reflex action we find that the muscle movements take place without any stimulus being transmitted from the brain. The sensory or afferent nerves are excited by the sensation travelling along their whole length till it enters the spinal cord, where the nerves have their centres. From these centres start the motor nerves, which cause the muscular action to take place; and from each centre a third nervous filament runs direct to the brain, by which the impression is intensified. If the sensory impression, instead of being transferred from the nerve centre to the brain, stay at the nerve centre, then the latter has the power of at once changing it into a motor impulse by exciting the motor nerve running to the muscle. The motor centre reflects the impression, and hinders it from being continued to the brain.

Numbers of movements performed in every-day life are reflex movements, and are carried on without any intervention of the brain.

All voluntary muscles have sensory as well as motor nerve fibres. These are the channels for the impulses which give rise to muscular sensibility.

The brain is the most complex structure in the human body. In the adult man it weighs from forty-five to fifty ounces; in the newly born child from ten to fourteen ounces. It reaches from thirty-five to forty ounces at the age of seven. It slowly and steadily declines after forty-five years of age at the rate of about one ounce in ten years. The average weight of the female brain is less than the male, amounting to about five ounces less in the adult.

LEVERS AND EQUILIBRIUM.

Levers: In the action of most of the muscles, and especially those of the extremities, we have examples of the three orders of levers. In the *first* the fulcrum lies between the power and the weight. The nodding of the head on the atlas, the tapping of the toe on the ground, straightening the elbow-joint, and the motion of the trunk on the hips are examples of the first order. Levers of the *second* order are those in which the weight lies between the fulcrum and the power. The leg when lifted off the ground as in hopping, and raising the body on the toes, are illustrations of the second order. In the *third* order the power is between the fulcrum and the weight. Bending the fore-arm on the arm, extending the leg on the thigh, the motion of the lower jaw, raising the ribs by the intercostal muscles, and raising a weight on the toes, are examples of this order.

The great advantage derived from the disposition of levers in the human body, whereby motion is gained at the expense of power, is seen in the various acts of walking, running, leaping etc.

The first order of levers, although the most powerful, is that least used in the animal economy, as its use is less productive of extensive motion. Therefore nearly all movements are performed at a mechanical disadvantage and loss of power.

The third order of levers is that most frequently met with in the human body, great rapidity and range of motion being conferred

by it. This is of much greater importance than a loss of power; for increase of strength can readily be insured by judicious exercise.

By the obliquity of the muscle attachments which occur in many instances, we obtain not only range but also precision, accuracy, and symmetry with the least possible expenditure of power.

EQUILIBRIUM: In walking and running, each leg is alternately active and passive—one swinging, relaxed from the trunk, which at the same time carries it forward, while the other is engaged in successfully fulfilling the four conditions of progression, viz., in imparting the required elasticity to the tread at the moment of impact; afterwards in balancing and supporting the body on the narrow basis of the planted foot; and lastly towards the end of the step, in pressing backward against the ground so as to urge the whole mass forward.

In standing, the limbs are employed only to support and balance the body; in progression, besides performing these functions, they have also to act as propellers and springs.

To maintain the *erect* position when standing, almost all the extensor muscles are in a state of contraction; therefore this position is the result of the accurately proportioned contraction of a multitude of muscles which oppose and balance one another. The body may also be supported *in any position* by such antagonistic contractions, provided its centre of gravity is situated vertically over any point in the space enclosed by the feet.

The head, resting upon the first vertebra, at a point of its base which is nearer to its posterior than its anterior part, cannot remain

in an upright position except by an effort of the muscles of the back of the neck. It is the cessation of this effort that causes a person to "nod" when falling asleep in a sitting posture.

The vertebral column being placed behind, all the organs contained in the chest and abdomen are suspended in front of it, and would cause it to bend forward unless the strong muscles of the back prevented it from doing so.

A similar observation may be made with regard to the pelvis, which by its conformation would bend forward upon the thighs if it were not kept back by the powerful muscles of the buttocks and hips; while those reaching from the ribs to the pelvis prevent any tendency to fall backwards.

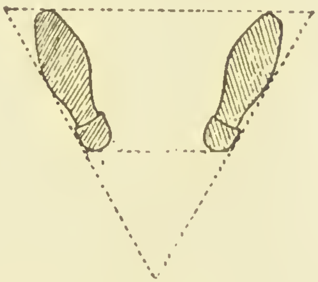
In front of the thighs are the muscles which, by keeping the knee-cap in position, are the means of preventing the knee from being flexed.

Lastly, the muscles forming the calves of the legs are the means of preventing the ankles from bending.

The position of the centre of gravity, however, varies more or less with every change in the relative positions of the parts of the body, ascending if the arms are raised, advancing or receding as they are thrown backward or forward, and following in like manner the various movements and inclinations of the head, trunk, and lower extremities. In all these postures, it is essential to the stability of the column, represented by the trunk, that a line dropped vertically from its centre of gravity, for the time being, should fall on some point within its base. For the fulfilment of this indispensable condition, we stand habitually with the feet so disposed as to furnish the most extensive area of support that can be maintained without fatigue, or an inconvenient separation of the legs.

When the feet are so placed that the distance between the outside points of the heels exactly equals the length of the foot, the greatest area of support will be obtained by turning the feet outwards at an angle of 60°. It may be said that the feet are unconsciously, and as it were instinctively, placed at or about this angle when it is desired to plant the body firmly in the upright posture. FIG. 36.

FIG. 36.



For drill purposes, and for uniformity in the performance of Physical Exercises, the heels should be closed, but the same angle must be observed.

The perfectly erect attitude of a person in the position of "Attention" is difficult to maintain for any length of time, firstly, because the basis of support is nearly the smallest possible, being merely the area enclosed by the feet with the heels together; secondly, because the column of the body is elongated to its greatest height, and the difficulty of preserving the equilibrium must be in porportion to the distance to which the weight is removed from the basis of support. The pernicious practice of compelling school children to "toe the line," with their feet parallel and touching, is to be condemned. In this position the basis of support of the

body is reduced to the least possible area, and the difficulty of preserving the equilibrium is thereby greatly increased.

In some systems of Physical Education, children are frequently ordered to stand at "Attention" with their feet at a right angle, in order to assist in the accurate foot-placing. This position is an unnatural one, and should be strongly condemned. If exercises necessitate some faulty position for their accurate performance, they should be omitted, and more rational ones substituted. The feet never require to be turned so far apart as to form a right angle when standing at "Attention."

The position of "Standing at ease" gives instant relief from that of "Attention," because the basis of support is enlarged, the centre of gravity changed, and the muscles which are chiefly engaged in preserving the perfectly erect position are relaxed.

To "Stand easy" still more completely illustrates this principle by allowing the individual to change and re-change his attitude at will, thus enlarging the basis of support, changing the centre of gravity with every change of position, and permitting easy and effortless alternation of action to muscles which have been engaged in single and rigid contraction.

In standing on one foot, the supporting area is of course reduced to the extent of the sole, which remains stationary, and the difficulty of balancing the body becomes proportionately greater. This difficulty is increased when various movements are performed with the raised leg or the upper limbs, and its maximum is reached when the heel is raised from the ground and the weight rests entirely on the toes of a single foot. In these positions of difficult equilibrium,

the least displacement of any one position of the frame requires to be compensated by a precisely equivalent movement of some other part in the opposite direction, without which the centre of gravity would be carried beyond the area of support, and the body would of necessity be overthrown.

The liability of the body to be overthrown is greatly diminished in the sitting posture, firstly by the enlargement of the basis on which the trunk rests, and secondly by the reduction of the height of the centre of gravity above the supporting surface. Hence in sitting, not only are the lower extremities relaxed, but the vertebral column itself is held erect with less exertion than usual, for which reason this posture is one of comparative repose. Perfect rest is only possible when the centre of gravity is so placed that the force of gravitation tends to *maintain*, not to *alter*, its position; a condition which, for a jointed framework such as the human body, can only be fulfilled in the *horizontal* or *recumbent* posture.

MOVEMENT.

To effect voluntary movement there must be in operation :—(*a*) The brain as the source of the will, (*b*) The nerves which convey the intimations of the will to the muscles, (*c*) The muscles themselves.

To excite the irritability of muscle and cause it to contract, a stimulus and intermediate agents are required. These are found in the brain, spinal cord, and the motor and sensory nerves. If the nerves in any part of the body be cut, a complete paralysis of the limb to which such nerves belong results, and no amount of mental stimulus will produce the least movement in those parts. The muscles have ceased to obey the will, and remain inactive. If the paralysed muscles were to receive a galvanic shock or were sharply pinched, they would contract and so move the bones to which they are attached. A severing of the spinal cord, or a lesion of the brain, produces similar inactivity of the muscles, but does not prevent the effect of the mechanical stimuli mentioned above.

Although contractility is an inherent quality of muscle, by which it indicates an individuality and a function peculiar to itself irrespective of any nervous influence, yet without the nervous stimulus it loses all power of mediation between the brain on the one hand and the agent on the other.

The nerves are powerless in themselves to produce muscular contraction, their function being simply to pass on to the muscles the stimuli received from the nerve centres or the brain.

There is a distinct and intimate connection between the movements of the body and those

of the mind. Persons of slow perception, and whose mental powers have never been awakened or cultivated, invariably move slowly and awkwardly; while on the other hand the movements of persons, whose mental powers are alert and active, are generally characterised by ease and briskness.

In all the movements of the body there is nearly always sympathy of action. Thus the lower limbs often aid in the force which seems to be located solely in the arms. A man seated cannot deal a blow with his fist so effectually as when standing, because he loses the aid of the force located in the muscles of the legs, loins, and abdomen. It is thus evident that muscular movements are not always localized; indeed an exercise may produce very beneficial results in a part of the body remote from the exact seat of the primary action.

Voluntary muscles are of two kinds, viz., *flexors* and *extensors*, which work antagonistically to each other. Flexors are those which produce action by approximating the bones and parts to which they are attached; while the extensors are those which produce an extending or straightening movement in the limbs, thus restoring them to their former positions. Such antagonistic action tends to control and balance muscular movement, thereby securing perfect accuracy and precision.

The co-ordination of muscular movement, *i.e.*, the precision with which the various antagonistic muscles in any group can regulate each other's actions, is perfected by judicious exercise. By long practice and with the association of ideas, it is possible to educate antagonistic muscles so as to ensure that they will ultimately work in perfect harmony. This co-ordination of movement is the result of the cultivation of

the *muscular sense.* It is by this sense that we are made conscious of the state of the muscles, enabling us to resist effort, and to regulate the amount of energy necessary to counteract the action of a certain opposing factor. Every movement requires the employment of a large number of muscles, and in order to gain precision of movement every muscle must generate a definite amount of force, *i.e.*, the muscles must co-ordinate in the execution of the movement. By this means each muscle contributes the amount of nervous energy which is just sufficient to produce the necessary contraction.

In performing voluntary movement it is necessary to discipline the various groups of muscles, and assign to each its own individual part in the work of the whole. Towards the furthering of this, the positions or attitudes of the body during movements play no mean part, but they must be carefully and frequently regulated before such movements can be said to be perfected.

The natural movements of the body are of two kinds, viz., *voluntary* and *involuntary.* The first are performed consciously by those muscles which are under the control of the will, and constitute *exercise* in the true sense of the word. The second take place unconsciously, and consist of the performance of the vital functions, *e.g.*, respiration, circulation, digestion etc., and also the exercise of all the muscles when they act involuntarily.

Exercises may be classed under two heads, viz., *active* and *passive.* Active exercises may be defined as muscular movements produced by muscular contraction. They are those in which the body is moved and agitated by its own force with or without the intervention of the will. Remedial gymnastics, or the artistic and

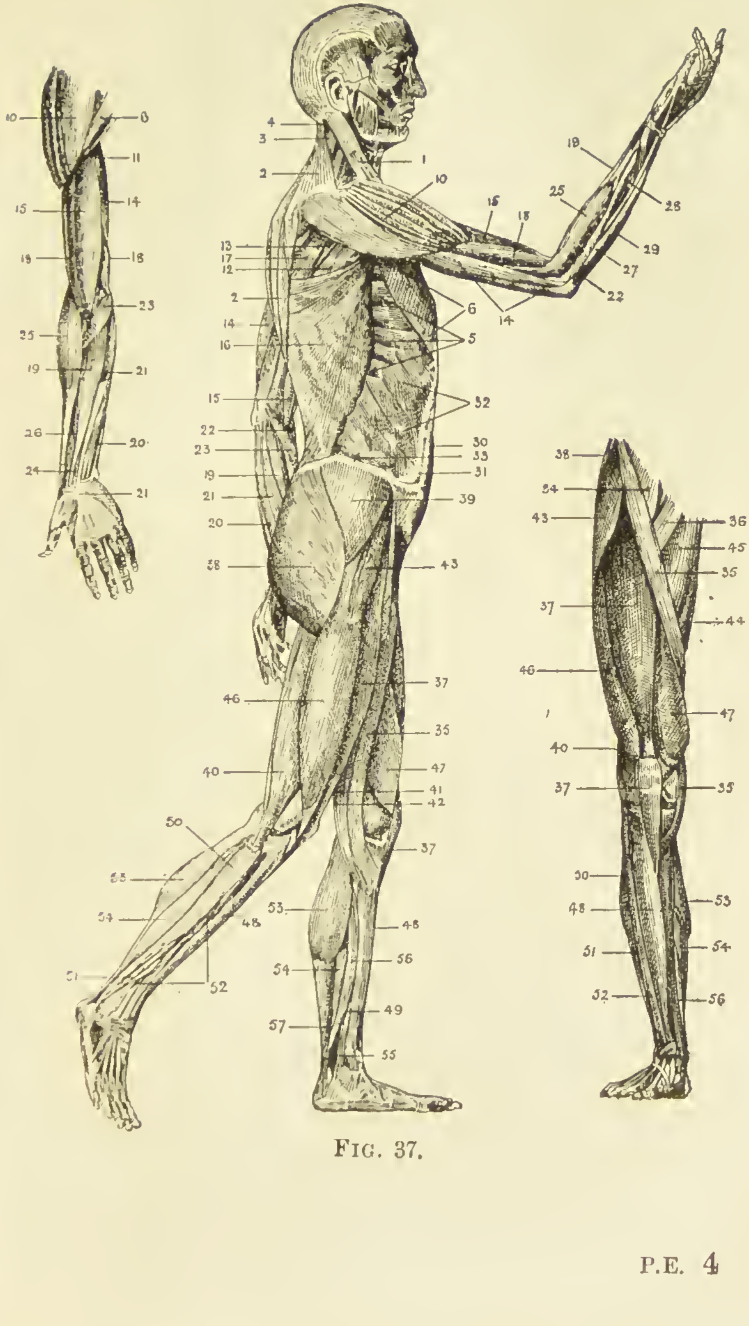


FIG. 37.

habitual exercise of particular parts with the view of augmenting the functions and power of certain muscles, may be included in the same class.

These voluntary exercises always produce a general excitement more or less powerful; numerous muscles and organs are brought into action, nutrition is widely distributed, and the beneficial effects are felt over the entire body.

Passive exercise, or massage, may be defined as a scientific method of treating ailments by systematic manipulations. In these the body is agitated and moved by a cause distinct from muscular action, although the muscles may assist by contracting sufficiently to preserve a fixed position. They are, strictly speaking, more specious than real, as it is almost impossible to set in action certain muscles without involving others in the movements. Passive exercises have a beneficial effect upon nutrition; they increase the strength and vigour in invalids and others, without causing much muscular or nervous excitement. The pulse is rarely quickened, very little or no increase of temperature is experienced, and perspiration is seldom produced. Such therefore cannot strictly be considered as exercises, as the limbs are moved without any effort on the part of the person under treatment.

In order to perform exercises which have been seldom practised, the muscles require a considerable amount of training to enable them to promptly obey the mandates of the will. This perfect command of body and limb is of the utmost importance in the physical culture of the young. Each muscle is replete with its own force, but is incapable of utilizing it advantageously until it has undergone such an amount of training as will enable its movements to become as nearly as possible automatic. FIGS. 37, 38, and 39.

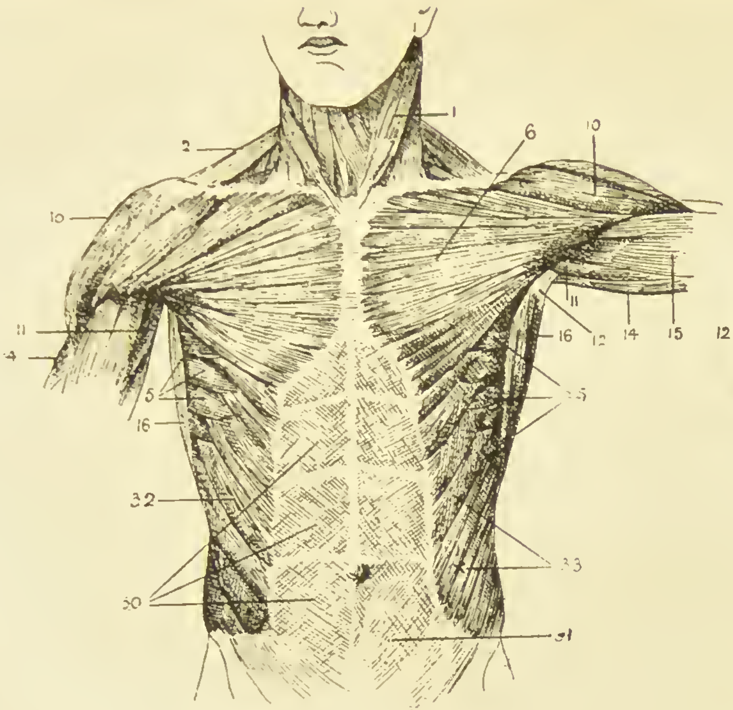

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Fig. 38.

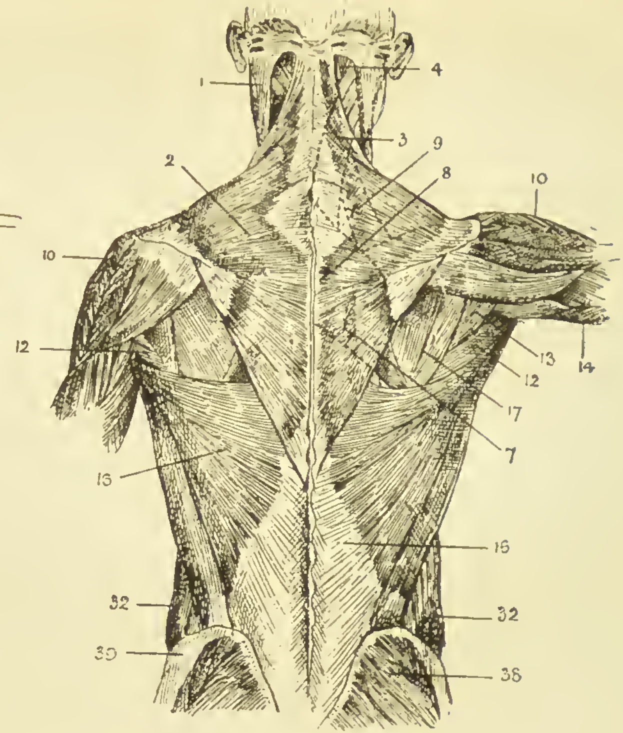
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Fig. 39.

PRINCIPAL MUSCLES BROUGHT INTO ACTION IN THE CHIEF JOINTS AND ARTICULATIONS.

HEAD. (Cervical Vertebræ.)

Flexion. *Sterno cleido mastoid (1), scaleni, longus colli.*

Extension. *Trapezius (2), splenius coli (3), rectus capitis, complexus (4).*

Lateral Inclination. *Levator scapulæ (9), sterno cleido mastoid (1), scaleni.*

Rotation. *Sterno cleido mastoid (1), trapezius (2), rectus capitis anticus major, splenius coli (3), longus colli.*

SCAPULA. (Shoulder-Blade.)

Forward. *Serratus magnus (5), pectoralis minor (6).*

Backward. *Rhomboideus major and minor (7-8), trapezius (2).*

Elevation. *Trapezius—upper fibres (2), levator scapulæ (9).*

Depression. *Rhomboideus major and minor (7-8), trapezius —lower fibres (2).*

UPPER ARM. (Shoulder-Joint.)

Abduction. *Deltoid (10), supraspinatus—if above the horizontal line, serratus magnus (5), trapezius (2).*

Adduction—*Before.* *Coraco-brachialis (11), pectoralis major—if limb raised (6), teres major and minor (12-13), triceps (14).*

Adduction—*Behind.* *Latissimus dorsi (16), teres major—if limb hanging (6).*

Flexion. *Pectoralis major (6), deltoid anterior fibres—if limb raised (10), coraco-brachialis (11).*

Extension. *Teres major (12), latissimus dorsi (16), deltoid —posterior fibres (10).*

Rotation—*Inwards.* *Subscapularis, teres major (12), pectoralis major (6), latissimus dorsi (16).*

Rotation—*Outwards.* *Infraspinatus (17), teres minor (13).*

FORE ARM. (Elbow-Joint.)

Flexion. *Biceps (15), coraco-brachialis (11), brachialis anticus (18).*

Extension. *Triceps (14), anconeus (22).*

Pronation. *Pronator radii teres (23), pronator quadratus (24).*

Supination. *Supinator longus and brevis (25), biceps (15).*

HAND. (Wrist-Joint and Fingers.)

Flexion. *Flexor carpi radialis (19), flexor carpi ulnaris (20), flexor longus pollicis (26), palmaris longus (21), flexor sublimus digitorum.*

Extension. *Extensor carpi radialis longior and brevior (27-28), extensor carpi ulnaris (29), extensor communis digitorum.*

TRUNK. (Dorsal and Lumbar Vertebræ.)

Flexion. *Rectus abdominis (30), pyramidalis (31), obliquus abdominis—externus and internus (32-33) proas magnus.*

EXTENSION. *Latissimus dorsi* (16), *rhomboideus major and minor* (7-8), *trapezius* (2), *multifidus spinæ.*

LATERAL INCLINATION. *Intertransversales, obliquus abdominis—externus and internus* (32-33), *quadratus lumborum, sacro lumbalis.*

ROTATION. *Obliquus abdominis—externus and internus* (32-33), *trapezius* (2), *latissimus dorsi* (16), *multifidus spinæ.*

CHEST. (RESPIRATION.)

ELEVATION—(*Inspiration*). *Diaphragm, intercostalis externus, pectoralis major and minor* (6), *serratus magnus* (5), *intercostalis internus—between costal cartilages, scaleni.*

DEPRESSION—(*Expiration*). *Intercostalis internus—between osseous parts of ribs, triangularis sterni, rectus abdominis* (30), *pyramidalis* (31).

THIGH. (HIP-JOINT.)

FLEXION. *Proas magnus, iliacus* (34), *sartorius* (35), *pectineus* (36), *rectus femoris* (37).

EXTENSION. *Gluteus maximus* (38), *obturator internus, semimembranosus* (41), *semitendinosus* (42).

ABDUCTION. *Tensor vaginæ femoris* (43), *gluteus medius and minimus* (39).

ADDUCTION. *Pectineus* (36), *gracilis* (44), *adductor brevis, longus, and magnus* (45).

ROTATION—*Inwards. Tensor vaginæ femoris* (43), *gluteus medius* (39).

ROTATION—*Outwards. Gluteus maximus* (38), *proas magnus, iliacus* (34), *obturator externus and internus.*

LEG. (KNEE-JOINT.)

FLEXION. *Biceps femoris* (40), *gracilis* (44), *sartorius* (35), *popliteus, semimembranosus* (41), *semitendinosus* (42).

EXTENSION. *Rectus femoris* (37), *vastus externus* (46), *vastus internus* (47), *crureus, these four called "Quadriceps extensor."*

ROTATION—*Inwards. Sartorius* (35), *gracilis* (44), *popliteus.*

FOOT. (ANKLE-JOINT AND TOES.)

FLEXION. *Tibialis anticus* (48), *peroneus tertius, extensor longus digitorum* (52), *extensor proprius pollicis.*

EXTENSION. *Gastrocnemius* (53), *soleus* (54), *tendo achilles* (57), *plantaris* (55), *tibialis posticus* (49), *peroneus longus and brevis* (50-51), *flexor longus digitorum* (56).

In the above classification of the muscles, the body is supposed to be erect, and each limb free.

The numbers following the names of the muscles refer to the diagrams, Figs. 37, 38, and 39. The omission of numbers indicates that the muscles are either so deeply situated beneath others, or in the thorax or abdomen, that they cannot be shown in the accompanying diagram. In a few instances muscles not situated externally are numbered, but in such cases a small cross is placed at the end of the indicating line.

The actions of the various muscles above mentioned may be reversed according as parts are free or fixed. Thus, the biceps bends the fore-arm on the arm; but if the fore-arm is fixed, as in climbing a rope, the contraction of that muscle approximates the arm and shoulder to the fore-arm.

CHEST AND LUNGS.

CHEST: The cavity of the thorax is the space enclosed by the spinal column, the sternum, the ribs, by certain muscles in the intervals of the bony framework, and by the diaphragm. In it the organs of respiration and the heart with its great vessels are lodged. The whole contents of the chest weigh, in the adult, about three pounds, irrespective of the blood.

The form and dimensions of the thorax differ in the sexes, and in the same individual at different periods of life. It is wider and shorter in the female than in the male. In the adult its transverse diameter exceeds that which is measured from the anterior to the posterior wall. The capacity of the thorax indicates the volume of the lungs, which usually bears a direct proportion to the development of the muscular system and the general vigour of the body. A well developed chest is the sign of sound health; a narrow, contracted one with a prominent sternum indicates an inherent weakness of constitution, and is frequently accompanied by a consumptive tendency.

The principal office of the thorax is to contain and afford protection to the lungs, and to force air alternately into and out of their cells. The middle region of its cavity is occupied by the heart.

Forming the floor of the thorax and separating it from the abdominal organs is a powerful muscle called the *diaphragm*, which is the chief agent in respiration. Its central part, which supports the heart, is a flat tendinous expansion;

while the lateral portions, which sustain the lungs, are composed of curved muscular fibres. By the contraction of the anterior and posterior portions of the muscle, the central tendon is rendered tense so as to become a fixed centre for the action of the lateral fibres; and being flat, and connected by short muscular fibres to the cartilage at the base of the sternum, it descends but slightly. The lateral muscular fibres on the contrary are very long, and arch upwards into the cavity of the thorax, reaching the level of the fifth rib. Each lateral muscular contraction tends to bring the whole length of its curved fibres into the same plane, and consequently enlarges the thoracic cavity.

The hoop formed by a pair of true ribs and their costal cartilages is inclined in two senses:—1st, the entire hoop is inclined downwards and forwards from its spinal to its sternal attachment, so that its anterior is lower than its posterior portion; 2nd, each lateral segment of the hoop is inclined downwards and outwards from the median plane of the body, so that the middle of the shaft of each rib is below the middle of a straight line connecting its extremities. To bring a rib, thus inclined, into a horizontal position, two things are necessary:—1st, its anterior extremity must be raised to a level with its posterior extremity; 2nd, its middle portion must be raised to a level with its ends. The former of these actions will carry forward the anterior extremity of the rib and the sternum, thereby increasing the antero-posterior diameter of the chest. The latter will carry the middle of the rib outwards, thus everting it, thereby increasing the transverse diameter of the chest. Therefore these two

actions performed simultaneously will dilate the cavity in both directions. Each rib is provided with muscles by whose contraction all its parts are brought nearer to the horizontal plane in which its posterior extremity is situated. These muscles act chiefly during inspiration; while the muscles antagonistic to them assist in restoring the ribs and sternum to the positions which they occupied before expiration.

The size of the thoracic cavity is constantly varying during life, owing to the movements of the ribs and the diaphragm. The horizontal measurements are increased in inspiration, the ribs and sternum being raised and pressed outwards, the former being slightly separated from one another; while in expiration they are diminished by the sinking of the sternum and ribs. The alteration in depth is due to the action of the diaphragm which descends when air is taken into the lungs, thereby increasing the cavity, and ascends when the air is expelled from those organs so as to restore the thorax to its previous size, or to diminish it in violent efforts.

Thus inspiration enlarges the thoracic cavity in three directions (1) longitudinally; (2) from side to side; (3) and from front to back.

Lungs: The lungs are two in number and are contained in the cavity of the thorax, one on each side of the spinal column. The base of each lung is hollowed in the centre and fits on the convexity of the diaphragm, following the shape of that muscle. The lung is of a somewhat conical form and takes its shape from the space in which it is lodged. The right lung is divided into three lobes, and the left into two.

The lungs of an adult weigh from forty to fifty ounces. The right one is about two ounces heavier, a little larger and wider, but an inch shorter than the left. The average weight of the lungs of a child from seven to fourteen years is twenty and a half ounces.

The tissue forming the lungs consists of minute recesses or cells in which the smallest branches of the air-tubes terminate. The spongy mass of the lungs is formed by the grouping of these cells into lobules, and by the aggregation of the lobules into larger masses or lobes. Each lobule is distinct from its fellows, and possesses its own air-tube, nerves, and vessels with which to carry on its function and nutrition. In other words, a lobule is a cluster of air-cells around a terminal branch of an air-tube.

The lungs are covered by two serous membranes called the *pleuræ,* which divide the thorax into two distinct cavities having no communication with each other. The pleuræ support the contents of these cavities, and prevent the weight of one lung from pressing the other when the body is reclining on one side. The inner surfaces of the pleuræ covering each lung do not, in their normal state, adhere but glide freely one on the other. The outer membrane on each side, the *pleura costalis,* is firmly attached to the inner walls of the thorax and to the diaphragm; while the inner membrane, the *pleura pulmonalis,* is firmly attached to the lung and closely follows its shape. The pleuræ are therefore conical, their apices projecting into the neck above the first pair of ribs.

In respiration, air is alternately drawn into and expelled from the lungs; but they are not completely emptied and refilled at each act

The most mobile part of the lungs is that situated nearest to the diaphragm, and diminishing gradually upwards to the apex.

Breathing consists of two rhythmical alternating processes, viz., inhalation, in which the muscles of the chest play their part, and exhalation, during which the elasticity of the lungs and the weight of the chest combined force out the air.

Tranquil breathing in the adult is from sixteen to eighteen times a minute, and after each inspiration the lungs contain about a gallon of air, the only purpose of which is to oxygenate the blood. From one and a half to two pints of air are taken into the lungs at each inspiration, and we breathe upwards of twenty-four thousand times in the twenty-four hours. Children breathe much more rapidly than adults, as their rate ranges from twenty to thirty a minute.

Capacity of lungs:—The amount of air passing in and out of the lungs at each respiratory act is from twenty to thirty cubic inches. This is called the *tidal* air. After the deepest possible expiration there remain in the lungs from seventy-five to one hundred cubic inches of air, termed *residual* air. An ordinary expiration leaves from one hundred and fifty to two hundred cubic inches of air, called the *stationary* air. The difference between the residual and stationary air is called the *supplemental* air. After the lungs have been inflated by an ordinary inspiration, it is possible, by an effort, to inspire from ninety to one hundred and twenty cubic inches extra, which is called *complemental* air. On an average the lungs contain about two hundred and eighty cubic inches of air.

The lungs, therefore, may contain as much as three hundred and fifty cubic inches, and as little as seventy-five to one hundred cubic inches of air.

The vital capacity of the lungs means *the amount of air which can be expelled by the deepest expiration after the deepest inspiration.* This averages for a man five feet eight inches in height about two hundred and twenty-five cubic inches; it increases with height up to six feet, then generally diminishes.

The capacity of the chest increases from about the fifteenth to the thirty-fifth year, in the average individual, at the rate of five cubic inches per year; from the age of thirty-five to that of sixty-five it gradually diminishes at the rate of about one and a half cubic inches per year. Thus the respiratory capacity of a man sixty years of age would be about thirty cubic inches less than that of a man of forty years of the same height and weight. Weight apart from height diminishes this vital capacity.

HEART, BLOOD, CIRCULATION, AND PULSE.

HEART: The heart is a hollow, muscular organ situated in the middle of the thorax in the interval between the pleuræ of the lungs; it lies behind the lower two-thirds of the sternum and the cartilages of the fifth and sixth true ribs, and rests on the diaphragm.

It is a double organ, divided longitudinally by a muscular partition called the *septum*. In the upper portion of each half is a cavity called an *auricle*, and in the lower portion of each half is a cavity known as a *ventricle*. Each auricle communicates by a valve with the ventricle below it, but no communication exists between the auricles or ventricles except through the media of the lungs. The muscular walls of the ventricles are of greater thickness than those of the auricles, while the left ventricle, having to propel the blood into the arteries, has exceedingly thick and strong muscular walls.

The arteries and veins are composed of three distinct coats, viz.—(1) the inner, a single layer of thin, elongated cells in contact with the blood; (2) the middle, formed of muscular and elastic elements; (3) the outer, made up of connective tissue by which it is attached to the tissues of the adjacent muscle. The coats of the arteries are thicker, stronger, and more elastic than those of the veins, so that in *post mortem* examinations they are usually found

open and elastic, even if emptied of blood, while the corresponding veins are usually collapsed and flaccid. The capillaries consist of one coat only, a continuation of the inner layer of the arteries, of which they are the minute prolongations.

The heart is the agent in the propulsion of the blood through the body; and into it, as the centre of the vascular system, veins enter, and from it arteries issue. Into the right auricle enter the two great trunk veins called the *superior* and *inferior vena cava*, and into the left auricle enter the four *pulmonary veins* bringing the purified blood from the lungs. From the right ventricle springs the *pulmonary artery* which, dividing into two branches, conveys the impure blood to the lungs; and from the left ventricle issues the *aorta* which is the great systemic vessel conveying the blood to the arteries. The *arteries* carry the blood to all parts of the body, and the *veins* complete the circulation by returning the blood to the heart. The *capillaries* are the minute blood-vessels connecting the arteries and veins.

Every large vessel of the heart, except the superior vena cava, is furnished with a valve. The use of these valves is to allow free passage to the blood in one direction, and to prevent its return by closing the mouth of the vessel. While the blood is entering the vessels the valves are flattened against the walls; but when the elasticity of the vessels acts on the contained blood the valves are forced towards the centre of the cavity, and arrest the flow of the blood in the contrary direction. Valves are also found in the superficial veins throughout the body, and act in a similar manner.

The average weight of the heart of an adult, is from ten to twelve ounces in the male, and from eight to ten ounces in the female. In children from seven to fourteen years it averages four and a quarter ounces. In the male it is about four and three-quarter inches in length, three and a half inches in width, and two and a half inches in thickness. In the female these dimensions are somewhat smaller.

BLOOD: The blood is the great medium of exchange between all parts of the body. It consists of a fluid containing innumerable microscopic solid particles called *corpuscles.* Of these there are two kinds, white and red. The white corpuscles are less numerous than the red, and are specially engaged as nutriment carriers to the tissues. They also protect the organism from the microbes of infection by absorbing them and rendering them harmless. They are most numerous just after a meal, and become fewer and less active the longer food is withheld. The red corpuscles, when charged with oxygen taken up from the air contained in the air-cells of the lungs, cause the blood to assume a bright red colour. During its course through the capillaries various changes take place in it. Every organ of the body is made up of a number of minute cells varying in shape and size, and as the blood circulates, each of these cells takes up oxygen from the red corpuscles, and other substances from the blood necessary for its nourishment, and gets rid of its carbonic acid. As the cells take up oxygen from the blood, the corpuscles lose their bright red hue and become purple in colour owing to the presence of carbonic acid. The nutritive elements contained in the blood are absorbed by

the tissue cells according to the requirements of each organ. To maintain the body in a healthy condition each cell should possess a reserve quantity of nutriment, so that when any particular organ is called into vigorous action this reserve may be employed to meet the immediate demands created by the extra work.

Circulation: On the contraction of the right auricle the blood is forced through the right (*tricuspid*) valve into the right ventricle; from thence by a similar contraction it is driven into the pulmonary artery and taken to the lungs. Here it comes into contact with the oxygen of the inspired air, and becomes purified, ready for redistribution throughout the body. The blood now returns by the four pulmonary veins into the left auricle, whose contraction propels it through the left (*biscuspid* or *mitral*) valve into the left ventricle, whence it enters the aorta to be conveyed throughout the system.

In the heart's action the auricles contract simultaneously, the ventricles acting in the same manner subsequently.

All the blood in the body makes the entire round of the circulation in about twenty-three seconds. The quantity of blood ejected from the heart of a healthy adult at each pulsation is estimated at from four to five ounces. The amount of blood in the body of an adult is variously estimated at from sixteen to twenty pounds.

There is a second system of circulation vessels—the lymphatic system. Its branches go to every part of the body, and collect waste matters, which are brought to the heart, and sent from there to the lungs to be purified. The heart does not pump the fluid that passes through the lymphatics. It is set

in motion solely by the movements of the muscles. When the muscles contract, the lymphatic vessels are squeezed, and their contents are forced onwards.

PULSE: The pulse is caused by the shock given to the blood by the overfilling of the aorta during the contraction of the left ventricle, and the distention and subsequent recoil of the arteries. It travels at the rate of from fifteen to thirty feet per second along the arteries, and is not felt in the capillaries and veins. Wherever there is an artery (containing arterial blood) a pulsation is felt. The pulse rate averages seventy-five times a minute, and is felt almost simultaneously in all parts of the body. In normal health it is about seventy in the adult male, and eighty in the female. In the newly-born infant it ranges from one hundred and thirty to one hundred and forty a minute; it diminishes to one hundred at three years of age, to ninety at ten years, and reaches the average at twenty-one years.

Posture influences the rate of pulsation, independently for the most part of muscular effort. In adults when standing the average is eighty-one, when sitting seventy-one, and when reclining sixty-six per minute.

The increased rate of pulsation is caused by the aspiration of the blood towards the muscles undergoing work. When in activity, all organs of the body draw towards them a greater quantity of blood than they do when in a state of rest. The blood is constantly flowing in the arteries, irrespective of pulse, at the rate of about sixteen inches per second.

Mechanical contraction accelerates the blood flow and pressure in the muscles during their movements.

AIR AND VENTILATION.

AIR: The atmosphere essentially consists of a mechanical mixture of two gases, viz., nitrogen and oxygen, in the proportion of about 79% of the former to 21% of the latter. It also contains a trace of carbonic acid, and differs in various localities as to temperature and moisture.

In ordinary breathing, only a small quantity of the oxygen contained in the air is consumed. During muscular exertion, the contraction of the muscular tissue produces a more rapid flow of blood from the heart. This accelerated flow causes deeper breathing, thus supplying a greater amount of oxygen to the blood as it passes through the lungs. In crowded assemblies a vast amount of oxygen disappears at every moment, being absorbed in breathing, and a large amount of carbonic acid is given out. The expired air is always from 97° to 99° Fah. in temperature and saturated with moisture. The oxygen is reduced to sixteen per cent. but the nitrogen remains unaltered; while the carbonic acid is increased four or five per cent., and in addition other impurities, chiefly organic, are found. It is estimated that about half-a-pint of water is given off from the lungs of an adult in the form of vapour every twenty-four hours.

The main purposes of respiration are to introduce oxygen into the blood for its maintenance; into the tissues as a means of aiding their nutrition, and as a necessary stimulus for their action; and to eliminate as quickly as possible the carbonic acid and other impurities which are constantly being formed in all parts of the system.

One per cent. of carbonic acid in inspired air will cause headache and languor. If this quantity has been produced by the repeated breathing of the same air, as in a closed or ill-ventilated room, the effects are more injurious, showing that other impurities accompany the carbonic acid. Ten per cent. of carbonic acid in the inspired air will speedily produce death in mammals. However slightly impure air may be, if breathed continuously a multitude of impurities must be taken into the system. From impure air arise all kinds of diseases of the respiratory organs, such as sore throat, cold in the head and chest, loss of voice, coughs, and consumption.

VENTILATION: Ventilation becomes urgent in proportion to the increased number of persons occupying a given space, and the amount of oil, gas, or coal consumed either for lighting or heating purposes. One gas burner will generally consume as much oxygen in a given time as five persons will. The air is rapidly deprived of its oxygen, while at the same time carbonic acid rapidly accumulates.

Frequently the heat of school-rooms is accompanied by a great degree of closeness, caused more by insufficient ventilation than by excess of heat from gas or fire. The results are most injurious, as the occupants are continually inhaling air which has been already breathed, thereby absorbing deleterious exhalations of others.

To secure perfect ventilation, the fresh air must be pure and should pass constantly into the room; it must not be too cold, nor must it produce a draught, and should be distributed equally to all parts of the room. If the air in a room is changed three times in the

hour each occupant requires one thousand cubic feet of air space; if changed four times, seven hundred and fifty cubic feet of air space will be required by each individual. In temperate climates the air of rooms cannot be changed more than four times in an hour without a draught being perceptible. In a schoolroom each child should have at least two hundred and fifty cubic feet of air space, and the air should be periodically changed during the absence of the scholars at recreation etc., by perflation or some other quick method. In a room in which physical exercises are performed, one thousand feet of air space should be allowed to each individual, as there is more need for air during exercise than during rest. It should be distinctly borne in mind that children need quite as much air as adults. For ordinary purposes the temperature of a room should be kept as near as possible at the mean temperature of the climate. The temperature most conducive to health and most agreeable for work is about 60° Fah.

In the heating of *school-rooms* precautions should be taken against rendering the air too dry—a condition which is hurtful in causing too rapid evaporation, not only from the air passages, but from the whole surface of the body. To obviate this, a vessel containing water may be placed on a stove, or before a fire, so that the vapour thus generated will tend to moisten the air in the room. Such a precaution acts as a preventive of head-ache, sore throat, and bronchial irritation.

When school-rooms are overheated, children seated near the doors and open windows catch cold in consequence of the draughts which

are produced, while the chill experienced on emerging into the open air is often the cause of stiff necks, catarrh etc. In breathing *very dry* air, the skin and also the lining membrane of the air-cells are injured; while *very moist* air impedes exhalation from, and stimulates absorption by, the lungs. *Warm, moist* air diminishes evaporation from the skin; but *moderately* warm, dry air is not injurious when breathed.

Open fire-places are preferable for heating purposes to hot-air furnaces or air-tight stoves. The warmth from an open fire-grate passes through the air of a room without overheating it, and persons and objects are warmed by the direct rays of the fire rather than through the heating of the atmosphere; consequently the air breathed is cool, and the occupants are *healthily* warmed.

Where an open grate is used, whether a fire be lighted or not, the various organic substances floating in the atmosphere of a room may pass off by the chimney. This is impossible when a closed stove is used for heating purposes, for then the impurities are scorched by coming into contact with its heated surface and are then redistributed in the air, giving rise to the peculiar smell often detected in rooms thus heated. This odour is generally the direct cause of the heaviness, inertness, and pallor noticed in persons who constantly live in an atmosphere so vitiated. Therefore, in addition to the comfort they afford, open fire-places supply an efficient means of ventilation.

In the ventilation of *school-rooms* it must be borne in mind that neither height nor cubical space is of permanent advantage unless provision is made for the free egress of the

vitiated air, which accumulates near the ceiling, and the ingress of fresh air. However great the cubical space of a room may be, it does not obviate the necessity for the removal of bad, and the supply of pure air—as the amount of air in any room is only sufficient for the occupants during a limited time.

Human exhalations contain a large amount of organic matter given off by the lungs, and skin. The offensive odour peculiar to a crowded room is caused by this organic matter, which is worthy of as much consideration as the carbonic acid. It plays an important part in rendering the air of a room impure, and it probably constitutes the difference between air poisoned by respiration and air which is merely deficient in oxygen or overcharged with carbonic acid. A person's breath is often charged with contagious particles which, when they reach a certain degree of concentration, can be detected by the smell, and are perceptible for a considerable time in spite of open windows and efficient ventilation. The condensed vapour of the breath, visible on the window-panes of crowded rooms, contains a large quantity of organic matter. This may be proved by placing a small quantity on a red-hot stove, when it will emit a peculiar smell like burnt horn.

It is most important that the cleaning of schoolrooms should take place in the evening, for, if carried on in the morning, the dust may not have time to settle or pass out of the rooms before the opening of the school. This is especially the case in winter, when the windows are closed in order to attain a certain temperature previous to the arrival of the scholars.

ABDOMINAL ORGANS AND DIGESTION.

Abdominal Organs: The abdominal cavity is the space enclosed by the spinal column behind, the diaphragm above, the structures that close the outlet of the pelvis below, and the powerful muscles, extending from the ribs to the pelvis, which protect the front and sides. This space is the largest in the body, its vertical measurement being greater than its transverse. Its dimensions can be influenced by the varying conditions of its boundaries. This cavity contains the stomach, intestines, liver, pancreas etc.

The alimentary canal varies in its form and particular functions in different localities, and consists of the gullet, stomach, small intestine, and the large intestine.

The *stomach* is an expansion of that part of the alimentary canal lying between the gullet and the *small intestine.* It is somewhat conical in form, its larger end lying to the left side. It is situated immediately below the diaphragm, to which it is attached by means of the gullet, and lies above the arch of the large intestine to the left side of the abdomen. In the adult it is about twelve inches long and four inches wide, and has two openings, that on the left communicating with the gullet, that on the right opening into the *duodenum* or the first part of the small intestine. It receives

the masticated food, and it is here and in the small intestine that the act of assimilation chiefly takes place. When the stomach is empty it is flattened, but when distended it becomes somewhat circular. The continuation of the small intestine from the *duodenum* is about twenty feet in length and consists of two parts, but no difference is perceptible between the termination of the one and the commencement of the other. It consists of a strong coiled tube formed of four layers as in the case of the stomach. Into this tube the food passes on leaving the stomach, and here it undergoes important changes.

The *large intestine* lies to the front of the body and forms an arch It is that part of the alimentary canal which extends from the termination of the small intestine to the surface of the body. It is about six feet in length but of greater capacity than the small intestine, being as wide again in some parts, while it occupies a more fixed position. It begins in the vicinity of the right groin, passes upwards, arches from right to left under the liver and stomach, and finally descends on the left side, passing through the pelvis to open on the surface of the body.

The large intestine plays but a very small part in the process of digestion, its principal office being to receive the indigestible portion of the food.

The alimentary canal is provided with muscular walls which, by their peristaltic contractions, propel the food onwards in its digestive course.

The *liver* is the largest gland in the body, and is situated on the right side of the abdomen just below the diaphragm. In colour it is

dusky-red, and weighs from fifty to sixty ounces in the adult. It is from ten to twelve inches long transversely, and from six to seven inches from front to back. At its right end it is about three inches in thickness, but this is not uniform throughout. It is somewhat square in form, its upper surface being convex and in close contact with the diaphragm, while its under surface is concave and receives the convexity of the stomach and intestines. The substance of the liver consists of a collection of small bodies called lobes which are subdivided into lobules. It is abundantly supplied with blood-vessels, and is capable of containing about one-fourth of the whole blood in the body. The arterial blood comes direct from the aorta by the hepatic artery, and is bright red in colour. The venous blood is collected from the capillaries of the stomach, pancreas, spleen, intestines, etc., and enters the substance of the liver by the portal vein. The hepatic artery and the portal vein enter the liver together on its under side, and are bound together in the liver in one sheath or capsule. Reaching the lobules, they immediately branch into smaller capillaries, termed *interlobular* vessels. When they enter the lobules they are known as the *intralobular* vessels, and when subsequently collected in the centre of the lobule and passed under it to a branch of the hepatic vein, they are known as the *sublobular* veins. The hepatic vein eventually runs into the inferior vena cava, and so to the right auricle of the heart. The liver secretes the bile in quantity varying from thirty to forty ounces daily. The bile is stored up in the *gall-bladder*, which lies on the under surface of the liver. As the liver is attached to the diaphragm it partakes of the movement of that organ, descending during inspiration, and regaining its former level during expiration.

The *pancreas* is a narrow flattened gland, measuring from six to eight inches in length, about one inch and a half in breadth, and from half an inch to an inch in thickness. It is situated behind the stomach, and extends across the spine to the duodenum, the large or duct end lying in the curve formed by the latter. Its duct enters the duodenum in company with the common duct from the liver.

All the organs contained in the abdomen are invested by a smooth delicate membrane called the *peritoneum* which passes in folds between and from one viscus to another, attaching them to the abdominal wall. It serves as a support to the viscera, yet readily admits of the change of position caused by respiration and exercise. In the adult, the abdominal viscera average about eleven pounds in weight.

DIGESTION: Before food can be assimilated by the blood it undergoes important changes in the alimentary canal. It is first acted upon *mechanically* in the mouth by the teeth, and afterwards *chemically* by the *saliva*, the *gastric juice* in the stomach, and in the small intestine by the *bile* and the *pancreatic* and *intestinal juices*. The gastric juice converts the nitrogenous portions of the food into *chyme*, which is absorbed by the blood vessels of the stomach.. The remaining portions of the food are changed by the bile and pancreatic juice into a milky fluid termed *chyle*, which is absorbed by the lacteals of the small intestine, carried by them to the thoracic duct, and poured into the blood by way of the left sub-clavian vein which enters the superior vena cava.

FOOD, CLOTHING, AND ANIMAL HEAT.

Food: Food is required by the body for three purposes, viz.: to generate heat, to produce force, and to encourage growth, thereby preventing deterioration. Anything, liquid or solid, which contributes to the nourishment of the body may be considered as food.

By means of food all our actions are performed. It should be taken at regular intervals, and be sufficient in quantity and proper in quality. With regard to quantity, a pound and a-half to two pounds of liquid and solid food are required for the daily wants of the ordinary adult, and of this quantity about one-fifth should be nitrogenous, or flesh forming.

Of all foods fat is the one which is most productive of heat, whereby the bodily energy is maintained. In northern latitudes vital energy is chiefly maintained by the consumption of animal food, the greater portion of which is fat; while in warm climates a vegetable diet predominates.

Experience teaches us that three meals a day are good for our civilized condition. An interval of about five hours should elapse between any two meals, so that the stomach may obtain a period of rest, and that the system may assimilate the nutriment from the last meal before additional food is taken.

Dr. Combe says: "When persons are engaged in laborious occupations, which induce a rapid expenditure of material, or when growth is going on so fast as to necessitate unusually ample supplies, food should be taken both more

frequently and in larger quantities than when the mode of life is sedentary and unvaried, and growth is no longer going on. The interval between meals should be in proportion to the quantity consumed. A healthy child requires frequent supplies of food to furnish the materials of growth, and to repair the daily waste, which is more active in early life than after maturity.

"If a person has been engaged in severe and fatiguing bodily exertion just before taking a hearty meal, digestion is impaired in two ways. The stomach itself participates in the general weakness caused by the bodily fatigue; and, in the next place, the blood which was flowing copiously through the vessels of the muscles, to maintain their unusual action, still continues to do so, because sufficient interval has not elapsed to allow the excitement to subside, and a new distribution to take place towards the organs concerned in digestion. Consequently, the stomach does not receive sufficient blood with which to carry on its increased action. Food, therefore, should not be taken immediately after severe mental or physical exertion, nor should active exercise immediately follow a hearty meal.

"Among the wealthier classes, imperfect nutrition most generally arises from excess in quantity, or a too stimulating quality of food; but among the lower classes, from deficiency in quantity or quality, added to scantiness of clothing, want of cleanliness, and imperfect ventilation.

"Children who are prone to bodily exercise, and who live almost entirely in the open air, as many of those of the poorer classes do, require a larger proportion of food than those of the better classes. Not only is their digestion more vigorous, but the waste going on in

the system is much greater, and the nutritive functions are more active—the need for nourishing food being proportionately increased. Hence it happens that, in the wealthier classes of society, young children suffer most from overfeeding; while among the poorer classes they suffer chiefly from the opposite cause, viz., deficient nutrition. In both, defective nutrition is the result; but the mode in which it is brought about is very different in the two cases."

In order that exercise may not prove injurious to the system, and that the brain should not suffer from mental activity, it is necessary that the body should be well fed. The brain, actively at work, entails a greater waste of tissue than is incurred by bodily activity, and demands an ample supply of food for its recuperation, besides periods of repose, otherwise it will suffer and deteriorate.

Such forms of exercise as cricket, football etc., which involve a large amount of physical exercise, endurance, and expenditure of strength, can only be sustained by liberal supplies of nourishing food. If the quality and quantity of food in such cases are not sufficiently restorative, the materials of the body suffer, and persons taking part in these games exhibit every symptom of nervous exhaustion.

Assimilation of food is greatly accelerated by a liberal supply of oxygen to the system, and this increased assimilation leads to a gain in development and weight of body. To ensure perfect oxidation the muscles must be bathed in liquid. Water absorbed by the system increases oxidation better than any other fluid. It is dangerous to drink large quantities of cold water immediately after violent exertion, before

the body has had time to cool; but no danger is incurred when water is taken in small quantities during the continuance of exercise.

Clothing: The chief uses of clothing are to afford protection to the body from the extremes of temperature, and to assist in retaining the animal heat, thus preventing its too rapid radiation. All other uses will be found to resolve themselves into one or other of these.

The production of bodily heat is largely dependent on the quantity and quality of the food taken, while its radiation and consequent loss are obviated by the use of suitable clothing.

As a protection against cold, woollen garments are much superior to either linen or cotton, unless the latter be manufactured into a cellular material. Flannel is highly beneficial, as it absorbs the increased amount of perspiration resulting from vigorous exercise, and minimises the liability to chills, rheumatism etc. It is important to observe the necessity of assuming warm, dry clothing immediately after any exercise which induces copious perspiration. If the clothing be damp from perspiration it must be removed, and the body rubbed dry previous to a change of clothing.

Flannelette, though made wholly of cotton, is, owing to the disposition of the fibres, capable of retaining air in sufficient quantities to act as a non-conductor of heat. This gives it an advantage over any other fabric made from cotton, though, as a non-conductor, it is inferior to a purely woollen material. When flannelette becomes wet, either through perspiration or external moisture, it loses its power as a non-conductor, and then becomes vastly inferior to wool as an article of under-clothing.

Waterproof clothing should be reserved for very wet weather, and is most suitable for persons who are not taking active exercise when exposed to it. The greater value of several layers of clothing, as compared with a single garment, should be borne in mind. An extra layer, even of very thin material, next to the skin, is often very valuable as a protection against cold. A garment should not fit closely to the body, but should be moderately loose, so that a layer of air is interposed between it and the skin. A loosely woven material is warmer than one of an opposite texture. It must always be remembered that the source of animal heat is in the body itself, and not in the clothes. Proper food, coupled with a due amount of exercise, will produce heat, which will be retained by the use of suitable clothing. The best type of clothing is that which will retain sufficient bodily heat to induce the sensation of comfort, without causing fatigue by excessive weight.

Children's clothing should be so loose as to permit perfect freedom of movement in every limb and part of the body. Tight clothing should never be worn round the chest, abdomen, or armpits; and the use of garters, corsets, and high-heeled or narrow-toed boots should be avoided. Absolute freedom is strictly essential for the encouragement of growth; and the deepest inspirations should be possible without producing any restraint either across the chest or waist. The slightest pressure is sufficient to check the flow of blood in the veins. The arteries are not so easily affected, owing to the stronger structure of their walls.

Animal Heat: One of the most important functions of the body is the production of animal heat for the maintenance of the normal temperature, without which life would be impossible.

Heat is chiefly produced in the body by the chemical union of the carbon of the food with the oxygen of the air introduced into the lungs. Combustion ensues, producing heat and carbonic acid, the former being absorbed by the arterial blood and conveyed to all parts of the body, while the latter is expelled from the lungs in the expired air.

Our normal temperature is 98·4° Fah., and is irrespective of the external heat. A person's temperature taken at the surface of the body is not always of the same degree, as it varies at different seasons, different hours, and under different conditions. Thus glands produce more heat during the process of secretion; muscles by contraction evolve heat; and even mental exertion or excitement will cause the temperature of the whole body to rise to the extent of $\frac{3}{4}$° Fah.

In a normal condition of the body, the internal heat is always the same.

The actual temperature of the body as measured by a thermometer is but very slightly increased during exercise, owing to the cooling influence of the constant evaporation from the lungs and skin. It has been ascertained that, during muscular exertion, the temperature of the body is seldom raised more than 2° Fah. above its temperature when at rest.

The *friction* produced by the blood circulating in the tissues increases the temperature in those regions where the blood flow is most rapid. This increased temperature is transmitted with

the blood, and when it reaches the blood-vessels in the skin, it causes them to dilate and so increase their capacity.

Radiation causes the blood to cool rapidly as it passes through the skin; but this is momentary, as the blood immediately hurries on into the inner parts of the body. *Cold* causes the minute blood-vessels in the skin to contract, consequently more blood is retained in the internal viscera than is the case under normal conditions, and an uniform temperature of those parts is maintained.

The highest surface temperature of the body is found in the arm-pits, and averages between 97° and 100° Fah.; in the bend of the knee the temperature is 95° Fah.; and over the region of the heart it is between 94° and 100° Fah. The warmest blood in the body is that coursing through the hepatic vein, which conveys the blood from the liver, having an average temperature of 102° Fah. The lowest temperature is found at the extremity of the nose and at the tips of the ears, where there is a mean temperature of 75° Fah.

The skin on the left side of the face is said to be warmer than that on the right, but this peculiarity is not observable throughout the two sides of the body.

FATIGUE, BREATHLESSNESS AND REPOSE.

FATIGUE: Immoderate use of bodily exercise produces a state of discomfort termed *fatigue.* When this stage is reached we are warned that it is time to desist, that we have passed the bounds of moderation, and that if the work is further continued the health and perhaps life itself may be endangered.

Although fatigue depends upon the force, frequency, and duration of the contraction of muscular fibre, yet the brain seems to be the seat of the sensation by which fatigue is induced; and the closer is the association of the brain with the muscular actions, the sooner will the state of fatigue be reached. Those actions which are performed involuntarily and unconsciously produce little or no fatigue, and if any at all, it is certainly much more slowly brought about than is the case when exercises requiring mental concentration are performed. Therefore movements or exercises to be continued for any length of time must be chiefly involuntary, and must not require too sustained attention during their execution, in order that the sense of fatigue may not be too quickly induced. A large amount of work, if well distributed over the body, causes much less fatigue and is attended with less discomfort than will be produced by a far smaller amount performed by only a few groups of muscles.

Fatigue experienced after violent exercise is attributed to the presence, in the muscles and blood, of the chemical products resulting from

muscular action, whereby a profound disturbance of the electrical condition of the nerves is brought about. Rest is necessary in order to allow the electrical stimulus to be restored before work can again be resumed.

All exercise is performed at the expense of bodily tissue, but if it is continued too long the tissues degenerate and become unable to do their appointed work.

BREATHLESSNESS: Breathlessness is a state of distress generally resulting from immoderate exercise or too intensified bodily movements, and is caused by the excess of carbonic acid in the blood. Exercises requiring prolonged effort speedily produce breathlessness. In some instances breathlessness may precede fatigue, in others it may follow. Running and jumping rapidly produce breathlessness. These actions are performed chiefly by the muscles of the legs; and as the chest muscles have no connection with those of the lower limbs, such movements cannot have any direct muscular connection with the thoracic cavity in causing breathlessness. The employment of a large number of muscles, as in the case of the legs, produces a larger amount of carbonic acid than can be expelled by the lungs in ordinary respiration; therefore breathlessness will precede fatigue, as the muscles themselves have not lost their vigour.

The muscles of the upper limbs are relatively feeble compared with those of the lower limbs. In the performance of exercises by the upper limbs the muscles do relatively a smaller amount of work than the legs would perform in the same time, and fatigue will ensue before the lungs have become surcharged with carbonic acid; in this case fatigue will

precede breathlessness. Thus we see that the employment of large groups of muscles equalises the work, so that a very large amount will be accomplished before fatigue is experienced, although breathlessness has been induced. On the other hand if exercises are confined to the action of a small group of muscles, fatigue will be speedily brought about, but breathlessness will be delayed.

Another cause of breathlessness is *effort*, which produces a momentary stoppage of the respiratory movements, and thus impedes the elimination of carbonic acid by the lungs.

During excessive breathlessness a person undergoes marked changes of colour. Soon after the commencement of an exercise he feels warmer, as the circulation of the blood is increased, and the face becomes flushed. With the continuance of the exercise further changes are brought about; the flushed appearance is gradually succeeded by a general paleness of the cheeks, while the lips assume a purple hue. The paleness is due to an insufficient supply of blood to the capillaries; while the purple hue is the result of the darkening of the blood by the presence of an excess of carbonic acid, and is readily observable through the delicate skin of the lips. These opposite tints gradually merge into each other and produce a mottled appearance, which ultimately give rise to a ghastly hue spreading over the whole face. This is attributable to temporary bloodlessness which is caused by a diminution in the heart's energy. The heart, having lost energy in proportion to the intensity of the breathlessness, cannot send a sufficiency of blood to the capillaries—hence the bloodless appear-

ance in those parts. If continued further, breathlessness will finally produce a dull leaden hue, which is the forerunner of *asphyxia*.

By long practice a person is capable instinctively of regulating, by his respiratory power, the amount of energy necessary for the performance of prolonged exercise. The amount of carbonic acid produced by the muscles during action will not then be in excess of that eliminated by the lungs. Thus, he adopts an even rate of movement in running, walking, &c., so that he may not rapidly reach the state of breathlessness. Any exercise, forcibly executed and persisted in for a considerable period, not only causes the accumulation of an excessive amount of carbonic acid in the blood, but eventually leads to partial respiration, or *gasping*. The heart, being a muscular organ, and under the control of nerve influence, shares in the general enfeeblement of the system, its contractions will become more irregular and less powerful at the slightest effort, while the lungs become congested, and breathlessness ensues.

If a person has been subjected to excessive work producing violent breathing, the air-cells of the lungs are over distended, and may even be ruptured; consequently they cannot perform their proper functions, and the work of respiration is carried on over a limited area, and breathlessness is the result.

Prolonged and excessive fatigue, whether muscular or nervous, may be defined as *overwork*. The effects of overwork may be either *general* or *local*. Its general effects may be seen in the complete prostration of the physical and mental powers; on the other hand, its local effects are manifested in the loss of both muscular and

nervous power in some particular region of the body only. The indications that exercise is proceeding at such a rate, and to such an extent, as to produce muscular and nervous exhaustion, may be classed under two heads: (1) *external or visible;* (2) *internal or subjective.* Among the external signs may be mentioned general depression manifested in careless and slovenly movement, paleness of visage, shortness of breath, want of animation, lack of energy and promptness, and a general state of listlessness. The internal indications are headache, giddiness, drowsiness, loss of appetite, general debility, and loss of tone. The appearance of any of these symptoms should be a sufficient warning to desist from further exertion.

It is a most difficult matter to estimate overwork. In some persons the symptoms appear long before they do in others; the amount of work which an individual is capable of performing being dependent upon the constitution, disposition, and the amount of muscular and nervous energy possessed. There is seldom any danger to be feared from occasional overwork, even if the heart's pulsations reach as high as one hundred and twenty per minute, unless they are irregular. On the first indication of any irregularity of pulsation the work must cease, otherwise there is a risk of establishing palpitation.

REPOSE: If physical exercises are performed causing too great a call upon the strength of the lungs, far more carbonic acid will remain in the system than is conducive to vital safety. If *rest* be taken for a short period, the excess of carbonic acid can be eliminated, and the exercises may be continued in safety. During muscular exertion a large quantity of carbonic acid is exhaled

from the body as the result of the increased respiration. If the exertion be lessened, the rate of breathing will be slower, and the amount of carbonic acid will be proportionately diminished. This is especially noticeable during sleep, when respiration is less frequent, and fifty per cent. less of this poisonous gas is exhaled than is the case during active exercise.

If the muscles are moderately worked, and are replenished by sufficient and well-assimilated food, they increase in size and strength, and the body will fully respond to the strain it encounters This replenishing the tissues takes place not only while the exercises are being performed, but also afterwards, in the rest or repose which the body takes. Then it is that the waste material is carried away by the blood, while nutriment is taken by the same medium to renovate the minute cells which compose the tissues As this waste is constant, repose is strictly essential, so that nutriment may repair the losses sustained by the tissues during their activity.

Exercises necessitating excessive physical endurance cause fatigue, which may be felt for a considerable period after their cessation. This is not attributable to the accumulation of carbonic acid only, but also to an unusual quantity of *solid*, waste, nitrogenous matters, which may require a long time for their expulsion by the excretory organs. From this we see the necessity of repose, as during this period the waste matters with which the blood is loaded can be discharged from the body; the combustion of the elements forming the muscle structure can be minimised; the wasted and exhausted organs can be repaired and invigorated uninterruptedly

by newer and fresher blood; and nervous and muscular energy may be renewed, so that exercise may be resumed and continued with as much zest as before.

The most perfect form of repose is *sleep*, as then the great vital functions are diminished in activity, and the muscular system is at rest. Children grow most rapidly during sleep. When awake and active, the system is constantly disposing of the waste matters which are the results of its activity; but during sleep, the system is free to extend its operations beyond the mere replacing of worn-out particles—hence the rapid growth.

During sleep, muscular and nervous energy is stored up for the next period of activity. The functions of the internal organs are performed with their usual regularity, while the organs of locomotion, so actively engaged in the daytime, are in a condition of perfect repose. The need of sleep is proportionate to the amount of physical and mental exertion undergone.

There must be a due relation between work and repose, otherwise impairment of nutrition ensues. Excess of work will cause diminution of muscular and nervous tissue; while excess of repose will produce a similar result. The most beneficial results are obtained when the period of muscular action alternates with that of muscular repose.

Long continued muscular exertion will result in such an increased accumulation of waste products in the system that the excretory organs will be unable to eliminate them in sufficient time to prevent blood poisoning.

The heart is an organ which is incessantly at work, and is, *apparently*, an exception to the

rule necessitating the alternation of intervals of repose with intervals of work. This, however, is not the case, for between two successive beats of the heart there is an interval of absolute rest, during which the waste caused by action is repaired. This interval of rest is estimated at about one-third of the time occupied by the heart in one complete contraction. In this interval, or pause, the heart takes its repose; and it is a fact worthy of consideration that the working and resting periods of that organ are similar in duration to the waking and sleeping periods of the average individual.

This necessity for intervals of repose may serve to explain why the human being is bilaterally symmetrical, or double. Thus, by using both sides alternately man is enabled to continue his work for longer periods than would otherwise be the case; for while the muscles on one side of the body are contracting, those on the other side are relaxing, thus obtaining their necessary repose. To all persons, it is far more fatiguing to maintain the erect position when standing than it is to walk. The reason would seem to be that, in walking, each side of the body is brought into action alternately; while in standing erect, both sides are used simultaneously, and the muscles which maintain the body in the erect position being subjected to a prolonged strain, the sense of fatigue very quickly supervenes.

SKIN AND KIDNEYS AND THEIR FUNCTIONS.

SKIN: The skin forms a protecting covering over the whole of the body and consists of two layers, the outer, or *epidermis*, and the inner, or *dermis*. The epidermis is a thin, semi-transparent insensible membrane, scaly, furrowed externally, and smooth internally. It covers the whole surface of the body, except under the nails, and is reflected inwardly to line the different passages. The surface of the epidermis presents a multitude of minute openings. These are the mouths of the ducts of little glands which secrete the perspiration. The epidermis contains neither blood-vessels nor nerves, its offices being to protect the deeper layer of the skin, to defend the body from noxious substances, and to constitute the medium of the sense of touch.

The dermis is composed of closely interwoven fibres running in different directions. Its upper surface is firm and dense, and its lower degenerates into cellular substance. It has innumerable perforations for the passage of the various ducts and the hairs. It is copiously supplied with blood-vessels and nervous filaments, so that it cannot receive the slightest puncture without occasioning bleeding and pain. Like the epidermis it is thickest in the palms of the hands and the soles of the feet, while it is thinnest in the eyelids and lips, where the sense of touch is most acute. It is thicker on the back of the body than in front, and on the outer than on the inner side of the limbs; while over the flexures of the joints it is unusually thick. The average weight of the skin of an adult is ten pounds.

Deep in the skin, and coiled up beneath the

dermis, are innumerable tubes, each of which, if uncoiled, would measure about a quarter of an inch in length. All parts of the body are provided with these tubes, which are known as the *sweat-glands.* Their number varies considerably in different localities. In the back and neck they are least numerous, and rarely exceed four hundred to the square inch; but in the palms of the hands and the soles of the feet there are from three thousand to three thousand five hundred to the square inch. It is estimated that there are between two and three millions of these tubes in the whole of the skin. The ends of the tubes open on the surface of the skin and form the *pores.* The blood, circulating in the minute capillaries of the dermis, gives up its waste matter to these glands, which convey it to the surface, where it is given off as perspiration, containing ninety-nine per cent. of water with other matters in solution. The excretion of perspiration is continuous, but exceedingly variable. It may be visible on the surface of the skin in the form of water, and is then known as *sensible* perspiration; or it may pass off invisibly, being then termed *insensible* perspiration. The average daily quantity excreted by a healthy adult is estimated to be about two pounds. A high temperature of the atmosphere, vigorous bodily exercise, exhilarating emotions, good general health, sudden fear, and nervous debility will render perspiration more copious. A healthy skin is always perspiring and therefore always moist, showing that it is exercising its chief function. During exertion the sweat-glands act more energetically than they do when the body is at rest. When the surface of the body is chilled by cold, or during prolonged inactivity, the skin contracts.

The circulation then becomes impeded, sensation is blunted (severe wounds may be sometimes unconsciously received), the fibres contract, the hair-tubes project and cause what is known as *goose-skin*, and perspiration is checked, whereby effete matter, which should have been expelled through the skin, is expelled by the extra work which is consequently thrown on the other excretory organs. When the surface of the body is warmed the circulation in the skin and adjacent tissues is active, touch is most acute because the nerves receive an abundance of stimulating blood, and perspiration takes place freely.

The most important purposes of the skin are to act (*a*) as an organ of excretion whereby effete matter is expelled from the tissues in the form of perspiration; (*b*) as a joint regulator of the heat of the body, by carrying off superfluous animal heat, and rendering the temperature almost uniform, irrespective of climate; (*c*) as the seat of touch, by which we are enabled to judge the qualities of bodies, such as hardness, softness, roughness, smoothness, size, shape, weight, and temperature.

The functions of the skin are as important as those of any other organ, and their perfect performance is most essential to ensure a healthy body. They cannot be properly performed unless the skin is kept thoroughly clean; therefore, *cleanliness* is indispensable in securing and maintaining health. *Perspiration* is the only natural means of accomplishing that end, providing the body is well rubbed immediately afterwards, or thoroughly washed. There can be no proper cleansing of the skin without copious perspiration, and this is a powerful argument in favour of *vigorous exercise.*

KIDNEYS: The kidneys, or renal organs, are two bean-shaped bodies situated in the lumbar region. In a well-fed person they are enveloped in fat. The right kidney, owing to the liver being above it, is slightly lower than the left. Each kidney, in the adult, is about four inches long and two inches broad. The concave portion of each kidney is turned towards the spine. In this particular portion two blood vessels are found—the renal artery and the renal vein. The renal artery supplies blood to the kidney, while the renal vein conveys the blood from that organ to the inferior vena cava. Dissected lengthways, the kidney shows three distinct parts. Near the edge of the kidney is seen a darkly-marked portion, where the great mass of the renal blood-vessels meet and the urinary secretion takes place. Next comes a lightly-coloured portion composed of tubules, along which the urine, as it is secreted, runs till it gets to the apices of a number of projections in the substance of the kidney, termed pyramids. The third portion, called the pelvis, is somewhat hollow, and it is here that the urine collects after leaving the pyramids, to be subsequently removed by a tube—the ureter—which leaves the centre of the concavity and passes onwards to the bladder. Urine contains water, urea, uric acid, and other solids. It is increased in quantity when much fluid is taken, by the effect of cold upon the skin, or by the pores of the latter becoming choked.

GAMES.

GAMES, as a means of physical culture, are valuable from the fact that they supply two hygienic wants, viz.: *exercise and pleasure.* All games possess these two essentials in a greater or less degree. Those which afford amusement and yet do not require a considerable amount of muscular effort in their execution are denominated *recreative games.* Some demand much physical exertion while affording some amount of pleasure, and are termed *gymnastic games.*

The child, subjected to the discipline of the class-room, and wearied by the irksomeness of mental application, longs for a total change of occupation, and for some means of giving vent to its pent up spirits. This need is supplied by the healthy recreation afforded by out-door games. The cramped limbs have then free play, the strain of thoughtful study is removed, pleasing excitement usurps the place of mental concentration, respiration is quickened, the circulation is increased, and the spirits become buoyant and animated. Complete change has been brought about by the fulfilment of the great desire of childhood, viz., *motion.*

The most appropriate games for the young are those which provide free play for all the muscles of the body, require but little mental excitement, and admit of the unrestrained use of the voice. To such sports the young are instinctively addicted, and we find that the so-called "romping" boys and girls are generally those who possess the finest physique in after life, while as a rule, the "quiet" children are the most delicate as they

grow older. In arranging recreative exercises for children we must follow nature's law as exhibited in the gambols of young animals. With them, play is the only means by which they attain their bodily development; and the physical education of children, to be beneficial, must resemble play as far as possible, otherwise it defeats the end for which it was intended.

Recreative games possess the incomparable advantages of exciting ardour and emulation among the children, of encouraging their initiative powers, and of accustoming them to rapid and energetic action. In addition to developing the bodily powers, boys' games exercise a powerful influence in forming individual character. They promote good temper, self-control, self-reliance, endurance, patience, courage under defeat, promptness and rapid judgment. Mutual good-will, and the advantages of co-operation are taught by the companionship associated with the performance of games. Much of the success in after life may be attributed to the qualities developed in childhood by the healthy, spirited games of school-life. FIG. 40.

The beneficial effects of an early physical training are not entirely lost in after life, and although the person may be much occupied in other ways, advantage will be taken of every opportunity for indulging in some form of athletic work, from which physical and mental benefit may be derived.

Girls require games of as lively a nature as those suited to boys; but it is necessary in organizing such games that due regard be paid to the character of the female constitution, as the physique of girls is generally inferior to that of boys of similar age. In childhood,

Fig. 40.

Eltringham Street Board School, London, S.W.
VARIOUS GAMES IN PLAYGROUND.

exercise should be almost exclusively general, and should have for its object the foundation of good health rather than the development of muscular strength.

In the performance of *favourite* games, certain muscular actions are repeated a great many times, while others equally beneficial are seldom performed. Those muscles which are employed in the former games receive a greater amount of exercise than those which perform the movements of the less popular ones. Hence muscular development is not uniform; certain groups of muscles are developed, while others are comparatively neglected. In free games children indulge their individual propensities; they do just what their inclination tells them, and exert themselves to excel in those exercises for which they are specially adapted. The hardiest, most active, and vigorous receive all the benefits from these exercises, while the feeble and less determined children either hold aloof, or make efforts beyond their strength. In free games the method of movement is not defined beforehand, consequently the movements are frequently ungainly, are performed at random, and without any physical benefit in view. The children neglect posture and carriage, which a methodical physical training would foster. They walk, run, and jump as fancy dictates: they do not husband their strength, but expend it rapidly in the too vigorous performance of the various movements. They therefore lose the advantage which a systematic course of instruction would give them, viz.: of training their movements in a reasonable, well planned, and progressive manner. When a large number of children are taking part in free games, their exuberance of spirits

is apt to lead them somewhat beyond self-control, and to engender a love of horse-play and boisterous demonstration of enjoyment. There is need then for judicious supervision on the part of the teacher, and additional zest will be given to the enjoyment of the games if the teacher occasionally takes part in them. It is a remarkable fact that school children of either sex, in large towns, are often ignorant of those healthy popular games played by scholars in small country towns, or in public schools. Heedless, headlong running, shouting, screaming, and a general disregard of the safety of the younger children seem to be the distinguishing features of many of the so-called games indulged in by school children. Such games as these produce coarseness of behaviour, bullying, and selfishness, and may ultimately prove detrimental to the discipline of the whole school; therefore they should be discouraged.

Organised games are a form of play under discipline, and should be conducted in such a way as to ensure the enjoyment of the maximum amount of exercise and pleasure on the part of those participating in them. When left entirely to themselves, children are apt to become boisterous, and in some cases careless of the safety and enjoyment of those younger or weaker than themselves. To obviate this, there must be a due amount of supervision by the teacher, yet of such a kind as to remove from the children's minds all idea of unnecessary restraint. It will be sufficient for the purpose if the teacher suggest the method of playing the games, and check unfair or unseemly conduct on the part of the players, giving special heed to the interests of the weaker and timid members of the class. This will encourage the children of a retiring nature to join their companions, and they will experience a feeling of safety from the knowledge that the teacher is

among them, while the interest shown by him will add greatly to their enjoyment.

In all playgrounds, children may be noticed standing aloof from their companions, and evincing no desire to join them in the games. This feeling of timidity or indifference will disappear when the teacher takes part in the play, and as a result more general interest is excited, and greater enjoyment follows.

Whilst guarding against rough and boisterous behaviour during games, the teacher should not forbid the children to shout, for this is really of great benefit to them physically. On the other hand, should the shouting deteriorate into screaming it must be checked at once, as it tends to produce coarseness of behaviour, and is useless from a physical point of view.

If the weather be warm, it will add greatly to the enjoyment and benefit to be derived from games if children are allowed to divest themselves of their loose outer clothing. This will enable them to throw off all feeling of physical restraint engendered by tight clothing, and will permit of that freedom of movement so necessary to the complete enjoyment of play.

Games, if properly supervised, and performed in the open air, and in a place where sufficient space is provided, are in many instances far superior to physical exercises carried on in a confined space indoors; for, not only are the muscles exercised, and the circulation and respiration increased, but the blood is amply oxygenated. But when children are restricted to a limited area, as in the case in the playgrounds of the metropolitan and large provincial schools, games cannot be advantageously employed. It is here that systematic Physical Exercises are essential, ensuring to each child as

much healthy relaxation and exercise as time and circumstances will permit.

Valuable as games are from a hygienic point of view, yet they are not sufficient in themselves to constitute thorough physical training. They must be considered only as auxiliary to the regular systematic exercise which children ought to receive, as a part of the daily routine, at the hands of their teachers. Free games have the disadvantage of being largely dependent upon the weather, and generally require a large amount of space for their performance.

SWIMMING.

AMONG the various branches of Physical Education, swimming deservedly occupies a high position; for, by it, muscular development is powerfully aided, bodily strength and activity are greatly increased, the general health is improved, while the frequent exercise of the respiratory muscles is a powerful aid to chest development. The Greeks and Romans attached the highest importance to this art and regarded it as indispensable, the ability to swim being a favourable factor in the estimation of a man's worth as a member of the community.

Swimming, in man, may be defined as the art of sustaining and propelling the body in water. When the lungs are inflated to their greatest capacity, the human body is slightly lighter than an equal volume of fresh water, consequently it will float on the surface. When the body is immersed in salt water, which is denser than fresh, its buoyancy is still more noticeable. Quadrupeds, and bipeds other than man, as a rule swim easily, because their heads are so placed that little effort is required to keep the latter out of the water, and the actual swimming is attained by movements similar to those used for progression on land.

Man is the only animal that does not swim in the same position as is assumed when walking. Hence, the various positions adopted by man in swimming are not natural to him, and are only maintained by constant and prolonged muscular exertion, particularly of the chest and limbs. Breathlessness, especially in the case of

beginners, is thus speedily induced, whereby the respiratory muscles are vigorously employed, tending to their development, and increase in the capacity of the lungs. The arched form of the chest is thus promoted, while immunity from pulmonary disease is secured.

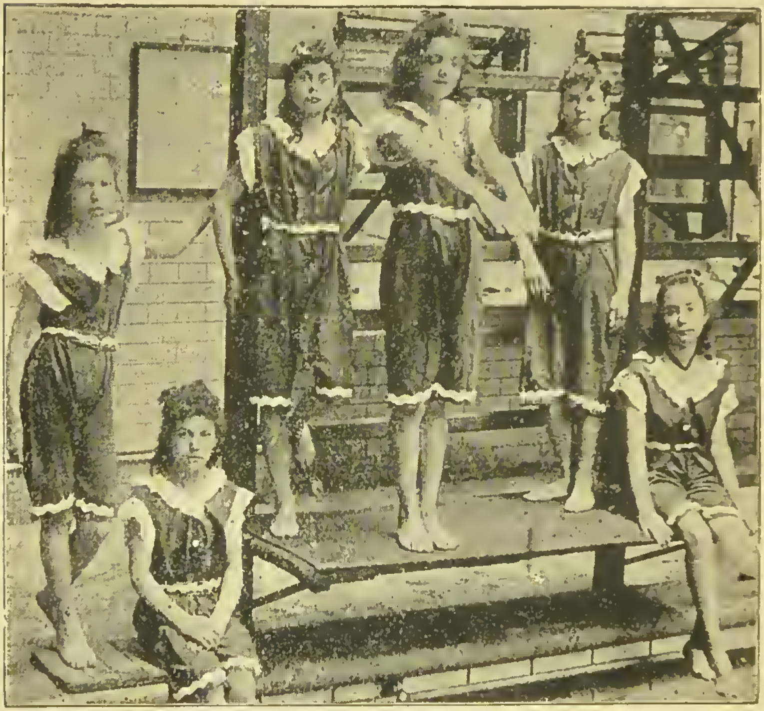
Swimming also produces an invigorating and hardening effect on the system, and when practised in moderation is of the greatest value in the preservation of health. A great strain is thrown on certain organs as well as on the muscles, and this, coupled with the effect produced by the cold water, may tax the strength of the most robust.

Extraordinary feats in swimming, as exhibiting speed or endurance, show to what perfection the art may be brought. This can only be attained by those who are physically fit; while, if attempted by the weak or delicate, may be highly injurious, and even dangerous to life. Swimming should be regularly and systematically taught in every school, not only as an accomplishment of vital importance, but also as a powerful aid to physical development. FIG. 41

In teaching swimming, the instruction and practice should be concurrent, *i.e.*, each position and motion should be separately taught while the beginner is by the *side of the water*, so that as each movement is acquired it may at once be put into practice *in the water;* for the basis of swimming lies in the correct and rhythmic movement of the limbs. Consequently, time spent in the teaching and perfection of so-called land drill, particularly when set to music, is actually wasted. The practice of teaching swimming (?) by means of land drill, without bringing the pupils into actual contact with the water, is absurd and valueless.

The mere correct performance of the movements on land only is of little value in teaching swimming; for, if a person so trained were suddenly brought into contact with the water for the first time, fear would undoubtedly prevent

FIG. 41.



GROUP OF SWIMMERS FROM CALEDONIAN ROAD BOARD SCHOOL, ISLINGTON, N.

any attempt being made to put the previously attained knowledge into practice. The difficulty experienced by beginners in sustaining the body in the water is chiefly due to spasmodic and irregular movements of the limbs induced by nervousness; therefore fear is the greatest draw-

back to the acquisition of swimming, in the case of adults as well as of children. Hence the necessity of overcoming it, as soon as possible, by actual practice in the water.

The natural result of immersion in cold water is a sensation of chill, which passes off after a short time, and is succeeded by a feeling of warmth, termed *reaction, i.e.*, the increased activity of various organs called forth by the action of the water on the skin. The colder the water, within reasonable limits, the sooner reaction sets in; and this is more marked among persons in the period of adolescence than among children or elderly persons, and in the male than in the female. Constant motion in the water greatly assists in promoting reaction.

Excessive exertion must be carefully avoided, as fatigue and cramp are induced by it, especially on the part of beginners. As a preventive of giddiness and cramp, brisk friction before entering the water is recommended. When seized with cramp, as the result of cold, the swimmer should not lose presence of mind, but should kick or strike out vigorously with the affected limbs. This may cause considerable pain at first, but with perseverance the cramp will invariably disappear.

A slight knowledge of the art of swimming may prove invaluable to individuals when in danger on the water. Many wrecks and boating accidents have occurred so close to land that persons have saved themselves by their ability to swim a short distance. Even when casualities occur far from land, the power to swim may often enable persons to keep afloat till assistance arrives, or till they succeed in reaching some object capable of affording support. With increased skill in swimming, a person's self-reliance

will increase, until, when he is a thorough master of the art, he feels confident of accomplishing the most difficult feats, even under the most adverse circumstances.

Apart from swimming being a valuable aid to cleanliness and physical development, the highest aim in view should be *the preservation of life;* consequently, when proficiency is attained, swimmers, especially children, should be taught to swim while fully dressed, and also to divest themselves of their clothing while in the water, old garments being utilised for the purpose.

The fact of being able to swim when in a bathing dress is in itself but a slight accomplishment, compared with the ability to swim when dressed in ordinary clothing. In nearly every case of accidental immersion it will be found that the person is either partially or wholly dressed; and although he may be able to swim in an ordinary bathing costume, his chance of saving himself, particularly in rough water, and when at considerable distance from land, is very remote.

Swimming develops the qualities of self-reliance, presence of mind, coolness, and courage. An expert swimmer will not remain content with the assurance that his life is comparatively safe in his own hands, but, as a result of his self-confidence, will be always ready to render assistance to others in danger.

The attempted rescue of a drowning person in deep water is a most dangerous undertaking for one who has but a slight knowledge of swimming, and may result in the death of both. Even when the rescue is attempted by an expert, great risk is involved; hence the necessity of every swimmer being practically ac-

quainted with the best methods of rescue. A practical knowledge of the approved methods of resuscitation is also highly essential; for many lives have been lost through want of skilful treatment of persons apparently drowned.

Having learned to swim, many persons, though not proficient, have attempted more than their newly acquired power would permit, and as the result of such temerity have lost their lives. Rashness, therefore, must be carefully guarded against, and nothing attempted which is likely to test a swimmer's powers to the utmost.

When the temperature of the air is low, especially if below that of the water, there is a great tendency to catch cold. A person of feeble constitution should avoid swimming in very cold water, and should not enter it when chilly, in a state of profuse perspiration, or excessively fatigued. Exercise should be taken preparatory to entering the water, in order to ensure a moderate degree of bodily warmth. If the surface temperature of the body is slightly increased by moderate exercise before entering the water, no injurious effects may be feared. The temperature of the water should range between 60° and 70° Fah., and when at the former great precaution is necessary. On no account should anyone enter the cold water after exercise of an exhausting nature, or when out of breath; neither is it advisable to bathe within two hours after a hearty meal, or when suffering from hunger.

When in the water, a swimmer should keep continually in motion, and should leave it at the first indication of chill. The body should then be vigorously rubbed, clothing speedily resumed, and when dressed a brisk walk should

be taken in order to promote the circulation of the blood, and to distribute it over every part of the body. Bathers should never leave the water for a time and then enter it again when shivering with cold; neither should they stay in the water till their teeth chatter—a sure indication that a reasonable point of endurance has been reached.

Shallow water is, as a rule, much warmer than deep. In deep water, the temperature of the surface is often several degrees higher than that at a depth of a few feet. Shady spots are always colder than those exposed to the sun, especially if the water is still. A fact which should be known by all bathers is that the apparent depth of running and standing water is always less by about one-third than it really is. Frequent and sudden alterations in temperature occur when cold springs or currents enter below the surface, and are a common cause of cramp when bathing in open water.

As a remedial exercise in cases of slight spinal curvature swimming is highly recommended. The evil results of faulty habits of sitting, standing, or walking are also counteracted by it. As with all physical exercises when systematically performed, swimming produces very beneficial results in the digestive organs. The greater supply of blood to those parts enables them to perform their functions more effectually, and thus prevents indigestion and its accompanying evils

RESPIRATORY MOVEMENTS.

THE lungs may be exercised *indirectly* by any kind of muscular exertion that will induce deep and rapid breathing; and *directly* by the employment of the voice in speaking, singing, shouting during play, or counting numbers when at drill. These are beneficial exercises, as they call into play all the organs concerned in respiration. This will ensure abdominal and natural breathing, which means that during inhalation the abdomen is forced outwards by the descent of the diaphragm, the lower part of the lungs being filled first; while during exhalation the abdomen is compressed, forced inwards, and upwards.

It is perfectly natural that during forced expirations the upper ribs should be raised and moved outwards, because the sudden and violent ascent of the diaphragm causes the air to be forced towards the upper parts of the lungs faster than it can find an exit by the *trachea* or wind-pipe. On the completion of the exhalation the ribs will again recede when making the deepest expiration. In a physiological sense the mobility of a person's ribs is of more importance than actual chest development.

Inspiration favours the return of the venous blood to the heart. It also assists the circulation of the blood in the pulmonary arteries, the expansion of the lungs accelerating the ingress of impure blood into those minute vessels for arterialization, and permitting the purified blood to flow readily through the pulmonary veins back to the heart for redistribution throughout the body.

Whilst the entrance both of the air and of the venous blood into the chest takes place during inspiration, so in like manner is the air expelled and an impulse given to the systematic circulation during expiration. The collapse of the lungs and the subsidence of the walls of the chest and abdomen, which take place during expiration, aid by their pressure the transmission of the arterial blood from the lungs into the heart, and also assist in propelling the blood along the large arteries, at the same time impeding the current of blood coming from the right ventricle into the pulmonary artery. From this it is evident that forced expirations should never take place slowly. Inspiration may therefore be considered as accessory to the venous, and expiration to the arterial circulation, the one aiding the heart like a suction, and the other like a force pump.

Deep breathing not only expands and strengthens the respiratory organs, but regulates the circulation. It expands the chest, and strengthens its muscles, particularly those between the ribs, thus ensuring greater breathing capacity. It purifies the blood by freeing it from carbonic acid and other noxious matters, lowers its temperature, and supplies the indispensable oxygen, thereby increasing oxidation throughout the body. At the same time it increases the nutrition of the lungs, obviates liability to consumption, or prevents its development in its earliest stages.

The process of deep breathing is as follows :—A deep, prolonged inhalation is made, the air being retained during a slight pause, followed by a forced expiration, which is succeeded by a pause of slightly longer duration than the preceding one.

Air is as essential to the lungs as food is to the stomach. Its importance may be estimated from

the fact that a healthy adult requires upwards of sixty gallons per hour. In inspiration, the air should reach the lungs through the media of the *nostrils*, as they temper, filter, and moisten the air before it passes to the lungs. The evil effects of taking into the lungs, through the *mouth*, air highly charged with particles of dust must be apparent to every one.

Vegetable and mineral poisonous matters and sometimes germs of epidermic diseases are found in the air, and will be readily introduced through the mouth into the lungs. Neglect of the precaution to admit air to the lungs by way of the nostrils may result in injury to the respiratory organs. Air breathed through the mouth is often the cause of toothache, and to the same source may often be traced such ailments as bronchitis and asthma. The *nose*, therefore, is the natural avenue to the lungs. It is provided with cavities which allow the air to be warmed before reaching the lungs; the secretions contained in these cavities absorb the impurities that may be present in the air respired; whilst the minute hairs which line the nostrils act as a natural respirator, excluding not only dust, but any bacillic germs which may be floating in the atmosphere, and which, if admitted into the remote air-cells of the lungs, might be injurious to the system.

It is, therefore, of the utmost importance that any person who engages in muscular exercises to any great extent should acquire a correct habit of breathing, so that the air inhaled may act throughout the whole of the lung capacity, and thus nourish the blood and remove its impurities. When the breathing capacity is increased the general health is improved.

Ordinarily, children, when at physical exercises, breathe altogether too superficially, the air being

inhaled in short, spasmodic jerks, and exhaled without little or any pause being made after the inhalation. Consequently, the lungs are never properly expanded, and certain of the air-cells remain undeveloped, and are therefore but little utilised.

There are two ways of cultivating correct habits of breathing, firstly by breathing exercises, secondly by such vigorous movements of various parts of the body, particularly the lower limbs, as will necessitate more than an ordinary amount of air being taken into the lungs to supply the demand. The breathing exercises should consist of long and deep inspirations through the nostrils, followed, after a pause, by forced expirations through either the mouth or nostrils, by which as much residual air as possible is expelled. The inspiration should be lengthened according to the age of the scholars, and may be combined with movements of the upper limbs, thus bringing into play the accessory muscles of respiration.

Nearly all slow movements, particularly those of the arms, can be made more effective—if the chest is not in a constrained position—by the introduction of deep breathing in unison with the movements. Such exercises tend to develop and strengthen those muscles which surround the shoulder girdle, some of which are powerful agents in assisting in the respiratory functions. *Forcible respiration* is beneficial in expanding the chest and strengthening the muscles which take part in the process. The volume of the chest is determined by the size of the lungs. If we wish to increase its girth we must *inflate all the air-cells in the lungs* rather than endeavour to *raise the ribs*. The pure air reaches the most remote air-cells, fills them, and thus increases the volume of the lungs. Forcible respiration, frequently and regularly repeated,

intensifies the inflation of the air-cells, and allows the hitherto closed and inactive cells to give entrance to the increased amount of air taken into the lungs. These air-cells associate themselves regularly with the ordinary respiratory work, and they readily perform their proper functions. More blood is thus supplied to the lungs on account of the increased capillary area, and their nutrition becomes more active; consequently greater oxygenation of the blood and increased bulk of the lungs result. The lungs, thus increased in volume, press against the chest walls in order to make room for themselves; and although the intercostal muscles raise the ribs in inspiration, and so favour the inflation of the air-cells, yet the lungs, by their increased bulk, greatly assist in the raising of the ribs, and give that vaulted appearance to the chest owing to its increased circumference.

To a class of beginners, respiratory movements should be taught at the commencement of a lesson, in order that a correct method of breathing may be impressed on the pupils, and practised at intervals during the remainder of the lesson. With a more advanced class they should be practised at the middle or towards the close of the lesson, as, having previously learned the correct method of breathing, the pupils may incorporate the more vigorous exercises with the respiratory movements.

If the children are fatigued, or if the least breathlessness has been induced, respiratory movements should not be practised, as they will then only be performed in an incorrect and spasmodic manner. They should not be executed in the open when the air is raw, cold, and moist; and during winter their performance in the open air must depend entirely on the state of the weather.

Children may be permitted to count the time

audibly when performing physical exercises. This is an excellent method of obtaining rhythm of movement and secures concentration of attention without entailing any mental strain. It also acts as a respiratory movement, and prevents the repetition of the exercises in order to secure precision and uniformity of movement; while the constant repetition of the words of command by the teacher is avoided.

Children are frequently taught that yawning is a breach of good behaviour. According to the results of late investigations it is the most natural form of respiratory exercise, bringing into action all the respiratory muscles of the chest and neck. The act of yawning is distinctly beneficial in two ways. In the first place, it serves the purpose of lung ventilation. The residual air, left in the deeper recesses of the lungs after ordinary respiration, in time becomes vitiated and affects the blood, and, through it, the nervous centres, and the result is a yawn. This is really a stretching of the respiratory chamber to its fullest capacity, and the filling of it with freshly inspired air which drives out the vitiated air. Yawning is also beneficial in opening, stretching, and ventilating the vocal, nasal, and auditory chambers in immediate connection with the mouth.

Breathing through the mouth after muscular exertion indicates that the exercise has been of more than ordinary severity. It may be generally accepted that, so long as a person can breathe freely through the nostrils with the mouth closed, the exercise has not been too severe, and little danger of heart strain is to be feared.

It may not be generally known that, when exposed to severe cold, a person may experience a feeling of warmth by repeatedly filling the lungs to their utmost capacity in the following manner:—Throw

the shoulders well back and hold the head erect; inflate the lungs slowly, the air entering entirely through the nose. When the lungs are completely filled, hold the breath for ten seconds, or longer, and then expel it quickly through the mouth. After repeating the exercise while one is chilly, a feeling of warmth will be experienced over the entire body, even in the feet and hands.

MILITARY DRILL.

THE term "military drill" is frequently misunderstood. In the minds of many persons it consists of handling a rifle as a weapon of offence or defence. To the soldier it means the movements, evolutions, formations, use of weapons etc., introduced in his training. As applied to the pupils in elementary schools it embraces the turnings, marching, movements, and simple formations required to enable them to assemble, to form classes, and to move from one point to another in an orderly and methodical manner. Military drill, in this latter sense, is insufficient as a means of physical culture, and should only be used as a supplementary measure in the physical education of children. Its use fails to bring the chest, shoulders, and arms into vigorous play, the muscular action being almost totally confined to the lower limbs. Still it has its uses, for it is strictly essential in the preliminary positions which precede the introduction of physical exercises. It teaches children to walk with a regular step and in a manner most conducive to a good carriage, and will prevent the common practice of foot-stamping in marching. It accustoms them to orderly formations, which may be advantageous in cases of panic, and indirectly shows them the value of co-operation, and the necessity and advantage of discipline. If used as an adjunct to such physical exercises as are calculated to invigorate the body, it will greatly assist in making the form erect, and the chest, shoulders etc., strong and well developed. Drill, in a military sense, involves a certain mental strain

more intense than that experienced when performing a code of physical exercises, as generally no familiar syllabus is being followed; children cannot anticipate the evolutions they are expected to perform; their minds are too closely intent upon the work, and thus little relaxation from school routine is felt. It is dependent in a great measure on the weather, and if carried on indoors requires for its performance a larger amount of floor space than is generally available in elementary schools.

In a systematic course of Physical Instruction, each exercise is designed to affect some particular group of muscles. This is not the case with drill in a military sense. Here the primary object is to teach the use of arms and such movements as will enable large bodies of men to move, in an orderly manner, from one position to another in the least possible time. Doubtless such drill does exercise and strengthen certain groups of muscles, but this is not the end in view. Still, the turnings, marching, and simple formations which are essential as a preliminary to Physical Exercises for children should be taught strictly on military lines, and by military words of command, in order to ensure uniformity in the method of instruction.

A carefully compiled system of Physical Exercises should include all that is essential, in a drill point of view, for the requirements of children, *i.e.*, it should contain such an amount of drill as will ensure the accurate performance of those formations and evolutions included in that system.

The object of physical training in the case of boys from ten to fourteen years of age should be the building up of a strong, sound, symmetrical frame, thus fitting our elementary scholars for any arduous calling which they might follow after leaving school.

The most fitting period for laying the foundation of a healthy, vigorous manhood is undoubtedly that of school life. The use of dummy-rifles is not advisable at this period of physical training, the aim of which is physical culture only, and not the use of any weapon of offence or defence. It is essential, however, that the drill taught should be of such a nature as to prepare boys for the more advanced training they would receive should they afterwards join Boys' Brigades, or Church Lads' Brigades, when the use of dummy-rifles is indispensable. The training at this period, being on strictly military lines, would lead up to the further training they would undergo should they subsequently join the auxiliary or regular forces. There would thus be a continuity in the training boys would receive after leaving school, enabling them to meet whatever demands might be made upon them in after life in the voluntary defence of home and empire.

The army authorities recognise the fact that military drill alone is insufficient for soldiers, and have introduced for their physical training a certain code of exercises to be performed first as free movements, and afterwards with dumb-bells, or with rifles as bar-bells — though the exercises have no connection whatever with the use of the rifle as an offensive or defensive weapon. This is followed by a systematic course of practical gymnastics on fixed apparatus.

APPARATUS (MOVABLE AND FIXED) AND MUSIC.

Movable Apparatus: When a certain standard of proficiency is attained in the performance of free movements, light movable apparatus should be introduced for the use of the children, particularly the elder ones, in order to bring the muscular sense—*resistance to effort*—prominently into action, without which no system of physical training is of material value.

A course of physical training with dumb-bells or wands should have in view (*a*) the co-ordination of muscular and nervous action, thereby securing grace, precision, and rhythm in the various movements; (*b*) the judicious selection of exercises which shall train the muscles as a whole, and not those of the upper extremities alone.

Muscular sense is acquired by muscular action, whereby resistance to effort is experienced, a knowledge of the relative distances of bodies is attained, and an estimation of their relative weights is arrived at, while we are made conscious of the degree of effort required in moving or raising them. Without muscular sense the muscles could not be maintained in such a state of contraction as is necessary for prolonged exertion. This sense also enables the nerves to communicate to the brain an accurate knowledge of the state and position of muscles when in action, and thus bring about the association of the mind with the muscular effort.

By the use of dumb-bells or wands in the training of children more physical benefit will be obtained, owing to the increased exertion required to

perform the movements. The various exercises may be modified, at the discretion of the teacher, by apportioning the weight according to the strength of each child, who will thus derive the maximum benefit with the minimum of physical labour. Muscular nutrition is more intense during slow sustained movements, because the blood is then distributed with greater regularity to all parts that are in activity. This cannot be said of exercises which need sharp, jerky, hurried movements for their execution.

The peculiar value of dumb-bells or other suitable movable apparatus is not immediately apparent. It will be realised by the teacher even more slowly than by the children. If dumb-bells be placed in children's hands, they immediately feel the necessity of performing an energetic muscular movement, and will, without any persuasion, continue to make vigorous movements. Now, let the children lay aside the dumb-bells; they at once lose interest in the movements, and all the efforts of the teacher will not induce them to perform an energetic action. They may endeavour to obey the different commands, and perform the various exercises, because they are well disciplined; but the exercises have now become an uninteresting task, and, therefore, prove irksome to them. Authority alone can now force them through the movements, because the interesting element has been withdrawn. They may continue to execute the movements ordered, and work in unison with their companions, but the evasion of the muscular effort will escape the eye of the teacher, and the exercises will produce no physical benefit, in spite of his earnestness and strict supervision

In the use of movable apparatus, the voluntary

muscles are made to do something more than to move the parts to which they are attached. They are not only employed in resisting an effort, but are working under the influence of antagonism, whereby co-ordination of movement is effected. Muscular contraction is directly proportionate to the amount of resistance offered, consequently the greater the resistance the greater will be the amount of muscular effort involved. Free movements, *i.e.*, exercises without any artificial resistance like that afforded by dumb-bells, clubs, wands etc., are quite sufficient for the physical education of very young children, but are of little value in the physical training of children who have attained the age of twelve or thirteen years. Therefore, free movements should be regarded as *preparatory* to exercises of a more advanced nature, which are subsequently to be performed with the aid of movable apparatus. All free movements should be executed with this object in view.

Free movements seldom entail the active tissue change and beneficial action of the skin, and of the circulatory and respiratory organs, as are produced when exercises are performed with movable apparatus.

Exercises with movable apparatus should be proportioned to the general strength of the individual. An equal amount of exercise cannot be well adapted to each pupil in a large class; for though they may be of an average age, still their constitutions etc., may present wide differences, and their physique may be far from uniform. The practical teacher should carefully note the constitutional peculiarities of the pupils under instruction, and should so judiciously apportion the exercise that no child will be

compelled to perform an amount of work for which it is physically unfit.

The employment of movable apparatus in the physical education of children should be carefully and systematically graduated as follows:—The use of dumb-bells should follow free exercises, and the latter should be of such a nature as to permit the use of dumb-bells immediately it is found that the free exercises are accurately performed. Thus, without any alteration, the movements may be augmented to such an extent as resistance will dictate.

The preparatory training in free exercises and in the use of dumb-bells paves the way for the adoption of wands. Although these do not provide such a variety of movement as dumb-bells, still their use is beneficial, particularly to the upper extremities, and is very interesting to the elder scholars.

The next step in the physical training of children is the use of clubs and sceptres. This necessitates a total departure from all previous exercises, whether elementary or advanced. Everything is now new to the scholars, and as club swinging involves a considerable amount of time, labour, and patience in its acquisition, and a considerably larger floor-space than is required for either dumb-bells or wands, it is evident that the use of clubs, although beneficial, lies outside the scope of elementary school work. A class of selected children may be trained to give a display with such movable apparatus; but this is not physical education in the true sense of the term. No ordinary class of scholars can be satisfactorily instructed in the use of clubs in the usual time set apart for physical culture in elementary schools. Free movements can be

easily supplemented by the use of dumb-bells and wands; but the movements required in club-swinging are of such a nature as to render it impossible, in the case of children, to lead up to them by any previous training.

The only kinds of movable apparatus which may be considered essential and beneficial in the physical training of scholars in elementary schools —particularly as large classes of children have to be instructed, irrespective of their individual physique, variation in age, and social position—are dumb-bells and wands.

Ambidexterity is best cultivated by the use of clubs or sceptres. Ball and dumb-bell exercises, and the various twisting movements with short wands—particularly those performed with a reversed grasp—are also valuable aids in this direction.

For the use of children, dumb-bells should range in weight from half-a-pound to one pound. They should be made of hard wood, not only to ensure strength and durability, but in order to lessen the bulk—large dumb-bells being very awkward to manipulate. The ends should be rounded; the handles should not exceed three-and-a-half inches in length, and must bulge in the centre, so as to fit into the hollow of the hand, the diameter of the bulge being not less than one inch. Wands should also be constructed of hard wood, and should range in length from thirty to thirty-eight inches, with a diameter of not less than three-quarters of an inch. A wand of these dimensions should weigh from one to one-and-a-half pounds. It is advisable that neither dumb-bells nor wands should be varnished, but kept perfectly plain, so that they may be frequently cleaned either by washing or sand-papering.

Fixed Apparatus: Exercises on fixed apparatus, such as horizontal and parallel bars, are unsuited to the physical training of young children. The muscular effort is too violent when a limited number of muscles are employed, and may seriously affect harmonious development. The muscular effort must be distributed over as wide an area as possible, in order to bring all the functions into greater activity without rapidly producing fatigue. This result will be most surely attained, in the case of young children, by following a systematic course of physical exercises, first as free movements, and subsequently with light movable apparatus. Such a course would admit, in its earliest stages only, the action of single groups of muscles. This early stage is necessary to allow certain muscles to recuperate while others are brought actively into play. Thus one group after another will be brought prominently into vigorous activity, fatigued, and rested. As the pupils attain accuracy and precision in the performance of the elementary movements, the various groups of muscles gain in strength and activity, and may gradually be brought into combined action in performing the more difficult exercises of the advanced stage. When this stage has been reached, exercises on fixed apparatus are useful, in the training of elder children, as tending to give increased muscular strength, and imparting confidence for the performance of more difficult movements. Exercises on fixed apparatus are better adapted to the promotion of muscular development than to the education of the nerve centres. This is attributable to the amount of physical energy required in the performance of the great majority of the movements. Vaulting, either over a bar or horse, is not suitable

for young children. Skipping will be found more beneficial for them, and will secure equally good results.

Every child should be taught the proper method of ascending and descending a rope, or a vertical or inclined ladder, as such an accomplishment may often be the means of saving life from fire or drowning. Very few children of school age could, in the case of danger, descend safely from the first story by a rope, while the majority would lack the ability or courage to descend by the underside of an inclined ladder.

MUSIC: The introduction of *music*, in order to facilitate the performance of physical exercises, particularly those for children, is found by experience to answer admirably. A judicious use of music will always succeed in securing promptness and precision in the various movements. In the performance of many exercises a great need of *rhythm* is felt. This want may be supplied to a certain extent by such simple means as the counting of numbers audibly, the tapping of a drum, or the use of the metronome. Regularity of performance may be thus obtained; but the monotony of the sounds employed soon becomes irksome to the pupils and the teacher alike, and some degree of restraint is necessary for the continuance of the regularity of the movements. Something is wanting to produce a spontaneity of action, and to infuse animation into the movements. This is best supplied by the aid of musical accompaniment. Music should not accompany all physical exercises, but only those which require regularity of movement, and which can be performed almost automatically. The beneficial results accruing to children from the practice of physical exercises can be best

measured by the amount of interest and pleasure evinced during their performance. Children love variety, both in work and recreation; and any device which will secure that object is a great adjunct, and is well worthy of employment. Music stands pre-eminent among all devices which are employed with this end in view.

The charm which music exercises upon the minds of children is a source of the greatest pleasure to them, and acts as an incentive, enabling them to exert a greater amount of energy in any given time, with less weariness of muscle and nervous strain, than is the case when music is not employed. With the aid of music, physical exercises become a delightful and exhilarating pastime, while the brain is comparatively at rest during their execution. Music has an educative influence upon the minds of children in developing their mental perception of tune, time, and rhythm, and in cultivating their musical taste. Its use during exercises, in addition to saving the voice of the teacher from over-strain in the continued use of words of command, also affords relief to the ear from the monotony of their repetition.

In adopting music to exercises performed by children, the teacher must use the utmost discrimination. It would be unwise to employ it on all occasions, as it might eventually result in the children becoming slovenly in their movements, thereby defeating the end which its introduction was intended to secure. When music is allowed as a special reward for precision in the performance of the exercises, a great interest will be attached to it, and the work will then be done with increased earnestness and thoroughness. Exercises which will not lend themselves, either wholly or

in part, to music, are totally unfit for the physical requirements of school children. In this case the fault lies with the system, not with the method of its application.

Some teachers of physical exercises absolutely exclude music, while others advocate its use on all occasions. These extremes generally fail to secure the desired object. The best method lies between the two.

One of the most beneficial results derived from healthy recreation is the complete rest from all mental activity. This can best be obtained by the daily performance of a few energetic physical exercises, accompanied by music. The constant repetition of movement, day after day, to mere word of command, with nothing to relieve the monotony, reduces physieal exercises to a dry, daily routine.

In the teaching of physieal exercises in schools, with a view to the subsequent employment of music, four distinet stages should be observed:—

(1) Eaeh series of movements should be taught by word of eommand, so that any faults could be at once eorreeted. The attention of the pupils is devoted to the performance of the exercises with precision as regards position, form and rhythm; and the fact that each movement requires a separate and distinct order seeures perfect attention.

(2) When improvement in the performance of the exercises indicates that mind and muscle are co-ordinated, numbers should be substituted for the words of eommand as far as practieable.

(3) When the exercises beeome still more familiar to the pupils—automatic in fact—they should be performed judging the time, or, better still, the pupils should be allowed to count the time audibly.

(4) When the exercises have been so engrafted

on the pupils that they perform them almost mechanically, and there is an indication that the exercises are becoming monotonous and uninteresting, music should then be introduced. A fresh stimulus is thereby given, and greater interest, smartness, finish, and physical benefit are the ultimate results. The exercises have now reached their recreative stage, and what was before deemed almost a drudgery now becomes a pleasure.

Children cannot be expected to entertain such a high opinion of physical exercises as the teacher cherishes; and, after a time, are inclined to regard the regular performance of the movements without music as irksome, no matter how often they may be reminded of the benefits they derive from them, and this through no fault of the teacher. The employment of music secures a more interested, and consequently a more satisfactory, execution of the work, while the beneficial effects of the exercises are in no way diminished.

Vocal effort during the performance of physical exercises, especially those demanding vigorous movement, is injurious to children, and should on no account be permitted. All exercises necessitating considerable muscular effort increase the respiratory need, so that the strain of the respiratory organs induced by singing, combined with the increased breathing, is too great for the strength of children. Still, vocal music may be advantageously used whenever instrumental music is not available. This vocal aid can be supplied by a class of children distinct from those performing the exercise, or by each half of the drill class alternately during the intervals of rest.

SINGING AND DECLAIMING AS PHYSICAL EXERCISES AND THEIR RELATION TO OTHER EXERCISES.

SINGING, reading aloud, and reciting are excellent physical exercises, as they bring into action about a hundred muscles. When singing is properly taught, that is to say, by a professional teacher, it enables children to produce definite voice sounds, to prolong and modulate notes, to inspire and expire at suitable times and intervals to produce these results, and favours a good attitude of the body. It is also useful in preventing or curing stammering and other impediments of speech, many of them caused by school work improperly performed. The attitude of the public singer or speaker is an admirable one from a physical point of view. The body stands erect, with the head raised, and the shoulders thrown back to allow of the free expansion of the chest and the enunciation of words and sounds; it is also a graceful attitude, and should be enforced on children. The good results of singing and speaking as an exercise must not be judged, however, by the loudness, softness, or sweetness of the sounds, as they are the results of minute variations in the vocal cords and larynx, but rather by the skill in producing and sustaining for a longer or shorter time one or more notes, and the consequent muscular control over the movements of the chest—in short, by good singing and not by the mere production of untrained voice sounds. The chief function of the teacher of singing is to show the pupil when

to draw in the breath to produce definite results, to avoid sudden and unsuitable interruptions, and to breathe in a deliberate and systematic manner; hence the warbling of airs or tunes to mark the time during the performance of gymnastic exercises is not singing in the proper sense of the word.

Again, singing is useless as a chest exercise when it is combined with exercises which require some muscular effort of the arms or legs, such as marching, dumb-bell, and bar-bell exercises, as we often see them combined in the drill in elementary schools for both sexes, and in girls' schools of all degrees. Singing may indeed be used in infants' and kindergarten schools, as it is an exhilarating occupation for infants, and no serious physical work should be required of children under the age of five or six years.

Further, singing accompanying active physical exercises is not only useless but injurious, as it counteracts any benefit which might be expected from such exercises. The chest is the fulcrum or fixed point on which the muscles of the upper extremity, the trunk, and to a large extent of the lower extremity, act. When a violent muscular effort is to be made, as, for instance, the lifting of a heavy weight or striking a blow, the chest is expanded to the utmost by a deep inspiration, and the breath is held by the closure of the vocal apparatus. On this fixed chest the muscles attached to the upper extremities, such as the large pectoral muscles, whose ordinary duty is to aid in the movements of respiration, act in the opposite direction and enable the arms to do the additional work required of them; but if the voice organs are set in motion, the chest ceases to be the fulcrum by the liberation of the

inspired air and the reversion of the chest muscles to their original function, and the consequent failure of the original object. It is only by a repetition of the process of drawing a deep breath and closing the glottis that the task can be accomplished, and by its repetition again and again for every fresh effort demanded. What is true of a violent muscular effort is true of muscular efforts in a minor degree, and it is obvious that the use of the voice and muscular effort are incompatible functions, and impede each other's performance, and their action cannot be simultaneous, as is often believed by teachers of gymnastics, but alternating one with the other. Hence singing performed under such conditions is always spasmodic and jerky, and the muscular efforts short and interrupted. As I have already remarked, the advantage ot singing as a chest exercise depends on the power to sustain and modulate voice sounds, and the benefit derived from muscular efforts of the body are also due to sustained efforts. Singing and physical exercises, therefore, necessarily interfere with the benefits derivable from each of them when practised apart. Singing and declamation are physical exercises which deserve more cultivation than they receive in this country; but to be effective and useful they must be practised apart from all other forms of physical training.

CHARLES ROBERTS, F.R.C.S.

SPINAL CURVATURE ETC.

THE *primary* or predisposing cause of spinal curvature in young children is debility of the component parts of the column, particularly the intervertebral substances; while inequality in length of limb and excessive use of particular muscles are but *secondary* or exciting causes. The deformity very rarely manifests itself before the child has attained the age of seven or eight years, and is more commonly met with among the poor inhabitants of large towns than among the rich.

The spinal column is maintained in its normal position by the equal contraction of muscles situated on either side of it. If the muscles on one side contract with greater force than those on the opposite side the spine will yield, and a curve will be produced, the concavity of which will be directed to the side on which the greatest contraction occurs. Thus among elder children lateral curvature may be caused by unequal muscular contraction.

It is worthy of note that the deformity rarely occurs among persons whose occupations compel them to maintain an erect attitude. Those who are accustomed to carry weights on their heads must of necessity assume this position, consequently the muscles of the trunk contract with equal force on both sides.

Spinal curvature may be divided into three distinct conditions, viz., anterior, posterior, and lateral. The *lateral* curvature of the spine is the most prevalent form of the distortion found amongst school children, and it chiefly occurs on the right side, *i.e.*, the convexity of the curve is to the right, resulting in the raising

of the right shoulder. A lateral curvature is named right or left according to the side on which the convexity of the curve is situated.

Any undue inclination to one side, if habitual, will cause a certain diminution in the thickness of the intervertebral substances on the side to which the body inclines, accompanied by a proportionate increase on the opposite side, and will in the course of time produce permanent distortion of the whole column.

If, owing to constraint or want of exercise, a due supply of blood be not afforded to the bones of the spine, their development will be retarded, and they will consequently yield more readily to any undue pressure. During childhood, these ill-effects will be more easily produced, as the component parts of the column are then of a cartilaginous nature, and the intervertebral substances exceedingly soft.

The child, kept daily seated at its tasks or compelled to stand during long lessons, suffers from want of change of position. It endeavours to relieve its cramped limbs by assuming that attitude which affords the greatest relief to the languid muscles. The child stands with its weight supported on one leg, generally the left, in order that the more active leg may be free. This throws out the left hip, depresses the left shoulder, and hollows the trunk on the same side. In this position the body and all the internal organs are thrown out of their normal vertical position, and the force of gravity still further exaggerates this result.

It rarely happens that the spine assumes one simple lateral curve from end to end; on the contrary, there are at least two in opposite directions, the upper one being called the *dorsal* and

the lower the *lumbar* curve. The first of these curves, whether dorsal or lumbar, is directly induced by some external cause; the second is produced by the necessity of restoring the balance disturbed by the curvature first set up. Hence the one is termed primary, the other secondary or compensatory, and they occur simultaneously. All positions which twist the pelvis, and cause unequal pressure on the thighs when sitting, are productive of lumbar curvature; while the overweighting of one arm in various occupations, and the habitual lateral inclination of the shoulders during school life are productive of dorsal curvature.

When the spine first curves laterally it also rotates, and in this movement it drags the ribs with it and deforms the chest. In rotation, the tips of the spinous processes (which are the only parts of the column which can readily be felt), move away from the side in which the lateral displacement occurs, consequently each vertebra is twisted horizontally, so that the tips of its spinous processes point towards the concavity of the curve. Eventually there is a stage of the condition when the tips of these processes will lie in a straight line, and yet the vertebræ will be considerably displaced. Coincident with this deviation, certain changes occur in the apparent size of the left and right sides of the thorax. The ribs attached to the convexity of the lateral curvature are drawn back, and the vertebræ, by their rotation, throw the ribs on the opposite side forward. Consequently the sternum will be displaced, one side of the chest will appear small and shrunken, while the other will be more prominent, and on a plane further forward than its fellow. In the earlier stages of lateral curvature, the curve,

particularly the compensatory one, vanishes when the person lies down, thus showing that muscular action is the principal factor in forming the latter curve. In a more advanced stage the curves are greatly diminished in the recumbent position, but do not entirely disappear, having become permanent.

A common spinal deformity, consisting of slight posterior curvature, frequently manifests itself among rapidly-growing school children, particularly in the case of boys whose ages vary from six to fourteen years. This is indicated by slight excurvation of the upper dorsal region (as seen in *round shoulders*), and slight incurvation of the lumbar region (lumbar curvature exaggerated).

The primary cause may be attributed in many cases to a slight constitutional weakness of the spine, or to debility arising from overgrowth. The exciting cause is the undue proportion of time devoted to sedentary pursuits, *e.g.*, writing on low desks, &c.

When spinal curvature exists in an early stage, it may be counteracted, in a great degree, by the employment of exercises which are calculated to promote the strength of the spinal column and the muscles associated with it. Such exercises as require a variety of attitudes in their performance are especially adapted to secure this object; but when the curvature has reached an advanced stage in adult life it is impossible to remove it entirely, although it may be partially remedied during growth.

Fig. 42 represents the natural position of the head, spine, and pelvis.

Fig. 43 indicates a primary curve caused by the unequal approximation of the lumbar vertebræ on the left side.

Fig. 44 shows the restoration of the head to the upright position by a compensatory curve on the right side.

Fig. 45 shows the secondary curves of the spine, the primary cause being lateral obliquity of the pelvis.

Fig. 42.

Fig. 43.

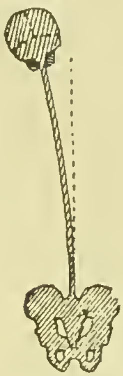


Fig. 44.

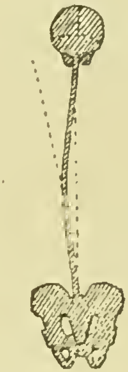


Fig. 45.

Positions Favouring Spinal Curvature, &c. —A girl, when carrying a child, invariably uses the same arm on all occasions. If this be the left arm, the child's left shoulder, being that furthest from the nurse, is lowered; consequently that side is hollowed, and the right shoulder is elevated through the arm being placed round the nurse's neck. This may be the means of laying the foundation of spinal curvature in both child and nurse, as the latter must lean to the right to counterbalance the weight of her charge. The habit which a child contracts of always lying on the same side of its body when at rest will tend to produce this deformity, or to aggravate it when it exists in its earlier stages.

In writing, children are apt to acquire the habit of sitting with an inclination of the body to the left side, the left arm resting on the elbow or hanging by the side. This causes an inclination

of the head to the left, and a consequent raising of the right shoulder, as is frequently noticeable during an arithmetic lesson, when children endeavour to prevent others from looking over their work. In this position the work is viewed obliquely, and one eye is nearer to it than

(a) FIG. 46. *(b)*

FRONT VIEW OF SCHOLARS WRITING AT A DESK, SHOWING A CORRECT AND AN INCORRECT POSITION.

the other; the chest is often cramped and distorted by leaning against the desk; and the weight of the body is generally thrown on the left hip, Fig. 46—47 (*b*). A child, seated on a

form or chair, will often assume such a position as will cause the weight of the head, trunk, and arms to fall on one hip without any apparent deviation of the lower part of the spine from the upright position. In this position the spine is drawn to one side, while the head and neck lean to the other.

Sitting with the arms *loosely folded in front of the body* is a posture which children frequently assume, or are made to assume, when at lessons. This is highly injurious, as the arms will invariably drop, causing the weight to be thrown on the abdomen; at the same time the shoulders and head are carried forward, the freedom of the diaphragm's movement is restricted, thereby impeding respiration, while the pressure on the stomach hinders digestion, Fig. 48 (*a*).

The common practice of compelling children to stand or sit for a considerable time *with their hands placed on their heads* must be condemned, as it is decidedly injurious in causing "poking head." This deformity is very prevalent with school children, and may chiefly be attributed to the forward inclination of the head caused by bending over the low desks at which they frequently study. The head being constantly inclined forward, this deformity will eventually become permanent, Fig. 48 (*b*).

If the seats are too high, children will place their books, when reading, close to the edges of the desks; and as a result their backs will be rounded, their heads "poked," and their chests contracted, whereby free respiration is impeded. Sitting on the edge of the seat, with the shoulders only resting against the back support, the legs extended to the front and the heels only resting on the floor, is a most faulty

position, and productive of the same bad results mentioned above, FIG. 49 (*b*). Some children will place their hands on the seat under the thighs, thus causing the legs to swing below; sometimes one leg is twisted round the other, or round the supports of the seats or desks. Other faulty

(*a*) FIG. 48. (*b*)

FAULTY POSITIONS WHEN SITTING, VIZ., A GIRL WITH THE ARMS LOOSELY FOLDED, AND ANOTHER WITH THE HANDS PLACED ON THE HEAD.

positions may be mentioned, among which are sitting with one leg tucked under the body, and sitting on the edge of the seat with the elbows on the desk and the head supported on the hands.

If the legs of young children are unsupported during long continued sitting, especially when the thighs are insufficiently supported, the latter may acquire a crooked form, and the children may suffer from cramp. The position of the foot-rest should be such as

(a) FIG. 49. *(b)*

A CORRECT AND AN INCORRECT POSITION OF SCHOLARS WHEN READING SITTING AT A DESK.

to permit of the feet being placed flat upon it without necessitating a sliding forward of the body on the seat. On the proper position of the foot-rest too much stress cannot be laid, for it is almost impossible for a child to

assume a posture favourable to lateral curvature of the spine if the feet are placed as above directed. Unsuitable desks and seats are extremely unfavourable to the healthy action of the lungs, stomach, liver etc., and are liable to produce spinal distortion.

Faulty positions are also frequently noticeable on the part of girls when at needlework. A common habit is to sit on one side, with the legs crossed, the back rounded and head frequently poked to such an extent that the chin rests on the breast. It is obvious that such a position is highly injurious not only to the spine but to the eyes. The spine is not only bent forward, but, owing to the twisted position, it is rotated, thus displacing various organs in the chest and abdomen; while the back rest, so highly essential in school life, is left unused, or supports one side of the body only. The eyesight must naturally suffer from such a position being assumed, particularly if fine work is needed. FIG. 50 (*b*). It is highly essential for every girl to be taught the use of the needle, but it is a question whether the fine work often demanded from scholars is beneficial in a hygienic point of view. If children have been taught, from the commencement of their school life, to sit in an erect position, no difficulty will be experienced by them in doing needlework when sitting upright. FIG. 50 (*a*).

Allotting to each scholar a particular seat in a class-room may often lead to a slight spinal deviation, and should the light be admitted from one side of the room only, slight defects of eyesight may be produced.

The description of the steps by which weakness of the back and habitual posture lead to curva-

ture suggests at the same time the means of preventing the curvature, or of correcting it in its earliest stages.

Watchfulness on the part of the teacher will prevent the children assuming faulty attitudes when at their lessons; and in order that they

(a) FIG. 50. (b)

GIRLS AT NEEDLEWORK, ONE SITTING IN A CORRECT, AND THE OTHER IN A FAULTY POSITION.

may clearly understand the reasons for assuming proper positions, and for avoiding faulty ones, the teacher should demonstrate each position, pointing out the advantages and disadvantages resulting from it.

All positions which tend to give predominance of inclination to one side are to be avoided. The habit of standing on one leg in prefer-

FIG. 51.

SHOWING HOW THE SPINE IS CURVED LATERALLY WHEN THE WEIGHT OF THE BODY IS CHIEFLY THROWN ON ONE LEG—IN THIS INSTANCE THE LEFT.

ence to the other must be broken, and the child taught to throw its weight, when resting, as frequently on one leg as on the other.

If one attitude is preferable to the other it is found in the military position of "Standing at ease." In this case the weight is thrown on the right leg, thus causing the spine to be laterally inclined to the right, throwing its convexity to the *left*, and so counteracting in some degree the prevalent convexity to the *right*. FIG. 51.

When standing at lessons, the scholars should not be compelled to close their heels, but should be directed to stand with their feet slightly separated. In this position the weight of the body will be equally distributed between the feet, little fatigue will be felt, the tendency to throw the weight on one leg is counteracted, and the common habit of placing one foot on the other is thereby prevented, FIG. 52.

The relative positions also of the desks and seats in some schools are frequently the means of causing spinal curvature, or favouring its development. This evil may be obviated by due attention being given to proper seating accommodation. If a faulty position is forced upon a child daily, such a position will in time become habitual. To obviate this, the edge of the desk should project one inch perpendicularly over the edge of the seat; thus any forward inclination of the trunk will be prevented. The seat should be slightly hollowed, slanting a little backward, and be provided with a back, in order to give support to the lower two-thirds of the spinal column during reading, etc. If no support be provided for the back the children soon tire with sitting upright, and will endeavour to find relief by leaning forward, thus rounding the back. The support afforded by the back of the seat should not extend above the hollow below the shoulder-blades. The desk should be at such a height

as to enable the pupil to place his fore-arms horizontally on it without carrying the trunk forward. This will ensure the work being placed nearly as low as the waist. The shoulders will thus remain square, and the arms will not bear

FIG. 52.

THE CENTRAL FIGURE SHOWS A CORRECT POSITION WHEN STANDING TO READ. THE GIRLS ON THE RIGHT AND LEFT ARE STANDING IN FAULTY POSITIONS.

any weight of the body. Flat desks are decidedly objectionable, as they cause children to stoop considerably over their work. For writing, drawing etc., the desk should be so arranged that it can be inclined towards the child at an angle

of about 20°. In leaning forward and bending the head over the desk, the return of venous blood from the head is retarded. This is frequently the cause of headache and defective eyesight among scholars.

In sitting upright, the thighs should be bent at right angles to the trunk, and supported for not less than two-thirds of their length on the seat, the height of which should be about two-sevenths of that of the scholar; the legs should be at right angles to the thighs at the knee-joints; the feet should rest flat on the floor or foot-rests; and, if the hands are not being used, they should be placed on the upper part of the thighs midway between the knees and hips. This position is one of great stability, as the centre of gravity of the trunk falls within a broad base; no dragging sensation is felt in the limbs; no fatiguing muscular action is induced; no undue weight is thrown on either hip, elbow, or hand; and the whole of the work can be seen at a glance. No strain is thrown on the ligaments of the spine; but, on the contrary, a proper position of the shoulders is thus permitted, and consequently no undue pressure is placed on the organs of the chest and abdomen. Fig. 49 (*a*).

Vertical writing is a means of securing a correct position when seated at lessons. When writing of this kind is performed for home-work, the teacher may be sure that the child assumed a tolerably correct position while at its task, for the position most favourable to vertical, or nearly vertical, writing is the upright one. The position secured by vertical writing obviates, in a great measure, the bending forward of the head, and the consequent tendency to the development of shortsightedness. Fig. 46—47 (*a*).

The proper lighting of class-rooms is of the greatest importance, and should receive the most careful attention, for on it greatly depends the maintenance of correct positions during school work. Perfect light is essential, but is of little use unless properly directed and diffused. The

(b) FIG. 47. (a)

BACK SUPPORT OF THE DESK REMOVED, AND SHOWING A REAR VIEW OF THE TWO BOYS SHOWN IN FIG. 46.

best means of admitting light is by the roof; failing this, light admitted from the left and slightly over the left shoulder is the best, particularly as a shadow will not then be thrown on the work by the interception of the hand.

When light is admitted from the right, the work is pursued under a disadvantage, owing to the shadow cast upon it by the hand, FIG. 53.

Light, both natural and artificial, is objectionable when received from *behind* the class, as it is trying to the eyes of the teacher, and causes the children's work to be shaded; neither should light be admitted from the *front* of the class, as it will prove injurious to the eyes of the children. For the latter reason a blackboard affixed to a wall should not be placed between two adjacent windows, if the latter are but a short distance apart, and unprovided with blinds. In order that blackboard work may be readily seen from all parts of a class-room, with the least strain on the eyes, the surface of the board should not be glossy but a dull black. Poor light is not only fatiguing to the eye, but it induces the pupils to poke their heads by bending over to bring the eyes closer to the work.

During the winter months such lessons as writing, drawing etc., should be taken in the morning or early in the afternoon; for if deferred till the later part of the afternoon session, the diminution of light will interfere with the proper execution of the work, and will necessitate the use of artificial light, which is not always desirable owing to the shadows produced by it.

Fig. 53.

EFFECTS OF CORRECT AND FAULTY ILLUMINATION. LIGHT FALLING FROM THE RIGHT CASTING A SHADOW ON THE WORK. LIGHT FROM THE LEFT THROWING NO SHADOW ON THE WORK, THUS ENABLING IT TO BE CLEARLY SEEN.

EFFECTS OF EXERCISE.

Exercise has a most invigorating effect upon all the bodily organs, producing a greater activity in the performance of their functions. By this increased activity, the whole bodily energy is augmented.

All forms of exercise do not produce the same effects upon the body. Some influence particular groups of muscles only; while others, which bring all parts of the body into vigorous play, favour increased action of the respiratory and circulatory organs, imparting a freshened vitality to the whole system.

Local muscular movements do not benefit the whole body; still any exercise which tends to strengthen any particular part will certainly produce a beneficial effect, however slight, on some adjacent part. The health is not appreciably improved by local movements, though they tend to develop the special groups of muscles concerned. This gives increased muscular strength, consequent on the development of the muscles which have been specially employed. This result is often due more to the frequency with which these muscles are exercised than to the intensity of the muscular effort required to perform the movements.

General muscular movements perfect the functional activity of the vital organs, while the tissues are invigorated by the greater nutrition resulting from the increased circulation. Respiratory movements are accelerated, whereby larger supplies of oxygen are conveyed to the blood. The lung tissue is improved by greater nutrition, which may obviate the liability to consumption.

The heart, as a muscle, is invigorated, and contracts with increased power; while the copious supplies of blood received by the lungs, skin, internal viscera, and the glands materially assist them in the better performance of their respective functions. In addition, the muscular fibres become stronger, more elastic, and respond more readily to the nervous stimuli. They are less easily fatigued, and when fatigue has been induced, they can quickly recover their lost vigour. These beneficial results accruing to the muscles are aided by the work of the joints in the body. Thus, in the extension and contraction of the muscles, the joints are brought prominently into play. Judicious training and rational exercise cause them to acquire great ease of motion; while neglect of exercise has been known to cause ossification of the joints, so that they could not be moved without causing excruciating pain. By exercise the calcareous salts are prevented from accumulating on the surface of the joints; great suppleness and easy mobility are established, which will continue to old age; while want of exercise frequently results in stiffness of limb, and premature muscular enfeeblement and degeneration. The bones are as much benefited by exercise as the muscular tissues. During growth, the exercise of the voluntary muscles acts powerfully on the osseous system. If the bones are duly exercised they participate with the muscles in the active nutrition which is taking place. Without exercise, a poor supply of blood is sent to those parts, resulting in deficient nutrition; while the cartilages, and consequently the bones, become weak and soft, and in many instances have been known to waste away.

A system of physical exercises may have

either of two objects in view. It may aim at strengthening and developing one particular set of muscles, or at giving a certain amount of exercise to every part of the body. This is what is meant by exercises producing either a *local* or a *general* effect. Some exercises designed for adults have the former object in view, but the latter should be the aim of all exercises intended for school children, special attention being devoted to those groups of muscles which are not brought prominently into play in every-day life. In order that a child may grow up with a well-proportioned, symmetrical body, it is obvious that *every* part should undergo judicious exercise; for any one set of muscles is too weak to withstand the strain produced by exercises which aim at developing that set of muscles alone. If local exercises only are taken with a large class, the more delicate children would soon be fatigued, while others could easily continue the exercise.

In general effect, the development is regular, the circulation uniform, and the whole body benefited by the exercise. When exercises are performed by a particular set of muscles so as to produce a local effect, the pleasure produced by its repeated performance is apt to create a dislike to all other forms of exercise.

Unless when the body is in a state of perfect tranquillity, which can scarcely ever happen except during sleep, the circulation of the blood throughout the system is constantly varying. Any muscular movement, however slight, increases the flow of blood in some parts and impedes it in others. Thus in some organs the quantity of blood is diminished, and in others increased, by every muscular movement. Those organs which

are called upon to perform particular functions receive an increase, while others whose offices are less urgent experience a diminution in the supply of the blood Every muscular movement, the state of the stomach, the varied positions of the body, and the condition of the nervous system influence, directly or indirectly, the circulation of the blood.

In order to discipline the muscles to prompt and harmonious action, all movements must be practised for a definite length of time. Exercise should be resumed frequently, but at moderate intervals, so that the benefits resulting from the increased action of the blood may be rendered more permanent. If this rule be observed, nutrition and functional energy will be properly balanced, providing that the amount of exercise be proportioned to the individual capabilities of those receiving instruction.

If immoderate exercise be taken, the muscles become overtaxed, and symptoms of fatigue and exhaustion are exhibited by those taking part in the work. The muscular fibres may be overstrained, the nervous energy exceeded, and the temperature of the body may fall below the normal, thereby increasing liability to such diseases as rheumatism and muscular inflammation.

Neglect of exercise lowers the vitality of the body; the strength diminishes, as little blood circulates in the various organs and tissues; while the muscular fibres lose their wonted vigour, and fail to respond readily to the commands of the will.

The object of teaching physical exercises in schools is to provide a means of recreation under discipline, and to raise the general standard of health by quickening the circulation, increasing the breathing capacity, promoting nutrition, facili-

tating the elimination of waste products from the system, increasing the volume and power of the voluntary and the functional capacity of the involuntary muscles, thereby promoting all-round bodily development and growth. As an aid to discipline, as a relaxation from the mental strain of class-room study, and as a relief from the prolonged cramped positions which are frequently assumed during lessons, systematic physical exercises are admirable.

Consequently exercises for children should have for their object, in addition to the above, the counteracting of the injurious effects resulting from undue restraint, and the assumption of faulty positions during school and home life. Thus such exercises may be regarded as *remedial.*

Exercise, whether as games or organized movements, is a source of health and bodily vigour, and consequently an incentive to mental activity. It is also beneficial in assisting the due performance of the vital functions, providing it is kept within the bounds of moderation.

The development of the muscular system is favourable to mental and nervous activity, as the laws which control nervous and muscular work are identical.

Systematic physical training renders the senses more acute; and as increased mental activity induces increased muscular activity, the body in general is materially benefited.

Physical exercises for the young must provide healthy relaxation, and should involve no mental strain. When a child's mental faculties are overtaxed, the best kind of exercise for it is that which requires no great mental effort in its execution. Exercises of an automatic character, *i.e.*, those that have become familiar to the child through long practice, are preferable to those in-

volving a certain amount of skill or mental activity for their accomplishment. It is irrational to expect the performance of exercises demanding mental concentration when the brain is already overtaxed. Teachers are thoroughly aware of the fact that prolonged mental activity necessitates a period of mental relaxation, and they endeavour to secure this by changing the subject of study. This only partially succeeds in securing the object in view, for mental fatigue will still continue, though perhaps in a modified degree. Complete mental repose can only be secured by total release from all intellectual occupation.

The control of the muscles needed for certain movements requires, at first, very close attention; but co-ordinate movements frequently repeated will, by intensifying the association between the motor centres and the corresponding nerve centres, increase the facility and rapidity with which the movements are performed, and enable the "memory of movement" to be cultivated. Thus co-ordinate movements, by frequent repetition, are performed with a minimum of consciousness, while accuracy of movement is slowly but surely developed. Spontaneity of movement, involving little mental concentration, is the result; and movements, which formerly required mental effort, have now become automatic.

Automatic movements necessitate no great mental effort, and fatigue produced by their performance is purely muscular. Hence it can readily be seen how immensely beneficial it is to engage in such movements when rest for both brain and nerves is required.

RULES FOR CONDUCTING A LESSON IN PHYSICAL EXERCISES.

THOSE who profess to be instructors of physical education should have a practical knowledge of the subject in all its branches. They should be capable of demonstrating all kinds of floor work, such as free movements, clubs, dumb-bells, and wands, and of performing practical gymnastics on all apparatus that is to be found in a properly-equipped gymnasium. They should also possess a practical knowledge of antagonistic exercises, out-door games, and swimming.

To acquire these qualifications, they should have received a thorough and systematic training in the theory and practice of physical education under qualified instructors, and should possess certificates or diplomas from recognised bodies of examiners setting forth their qualifications.

A person who is deficient in any one branch of the subject is unworthy to be recognised as a physical instructor, or to act as an examiner in the subject. The absolute proficiency of a physical instructor is a matter of the greatest moment to the general public, as well as to the frequenters of public and private gymnasia, besides being of vital importance to those who are responsible for the physical education of school children.

A distinguishing feature of any system of physical training for *school children* should be its *simplicity of acquisition.* Those whose duty it is to impart the instruction (and they should be the teachers) should be able to grasp its practical application after undergoing a course of about

twenty-five lessons, each of one hour's duration. Any system that cannot be acquired by the teacher in this time is unfit for the use of children.

Any system of physical training for school children of either sex, with or without movable apparatus, should be totally free from complicated or difficult movements, and yet be attractive. The movements should not require a great amount of either muscular or mental exertion for their performance, but should be of such a nature as to be readily learned even by the youngest children, and performed with grace and precision, and to musical accompaniment, with little or no alteration. Such exercises should be free from risk, and most of them of such a simple nature as to be practised in the brief intervals between the lessons. Nothing should be introduced which would necessitate the children's hands, clothing, or any part of the body *coming in contact with the ground.* They should not necessitate the wearing of a particular costume, but should be capable of being performed by the children *whilst dressed in their ordinary clothing, and should be acquired by the teachers under similar conditions.* These exercises must be independent of the weather, so that they may be performed either indoors or in the open air, according to the season.

To be successful in teaching physical exercises, those conducting them should be thoroughly conversant with the system employed, and its method of application; and in teaching children, the particular sections suitable to their age and strength. They must be capable of explaining in the simplest language what is to be done and how to do it.

The progress of the pupils depends almost entirely on the efficiency of their teachers. To

ensure success it will be necessary for the teachers to perform the movements accurately before the class, drawing attention as briefly as possible to any points that may be considered necessary.

All movements should be first taught, when practicable, by *word of command*, as they appeal to the scholars more forcibly, and aid in cultivating discipline, and in securing concentration of the mind during the exercises. *Numbers* and *judging the time* should only be resorted to when the scholars have learned the correct execution of a movement.

When demonstrating exercises the teacher should, as a rule, face the class; and when showing movements which are to be performed by one limb only, or by more than one in contrary directions, should demonstrate them in an inverse manner, *e.g.*, if the command be "Right arm upwards, left arm outwards—Stretch," the teacher should stretch the left arm upwards and the right outwards.

The teachers ought to make themselves thoroughly acquainted with the exercises before attempting to conduct them, as it is absolutely essential that every movement should be accurately demonstrated to the pupils in the first instance. After the children have thoroughly grasped an exercise, there is no necessity to illustrate it in subsequent lessons, occasional corrections excepted. Information conveyed to the mind through the medium of the eyes is always more firmly stamped on the memory than that received through the ears.

A pleasing manner and a good temper are most essential. While the class is standing at ease, the benefits derived from physical exercises can be briefly explained to the elder children, and the particular parts of the body which were most prominently

exercised in the preceding movements should be mentioned. If this point be carefully observed by the teacher, the children will not only clearly perceive the objects aimed at in each step of their physical training, but will better appreciate the work, and will consequently be more likely to practise the same in their leisure time. Teachers should consider the different capacities of their pupils, and be patient in those cases where inability to perform the exercises is coupled with apparent willingness.

Every command should be divided into two parts, the *cautionary or explanatory*, and the *executive.* Between the cautionary and the executive part a sufficient pause should be made to allow the children time to concentrate their attention.

All executive words of command should be preceded by cautionary words, which, as far as possible, should be of such a nature as to be indicative of the actual movement to be performed. This will ensure promptness of action with the least amount of mental strain. In other words, every executive command should have distinct cautionary ones peculiar to itself, and the parts of the body or limbs which are to be most prominently exercised should be named prior to the cautionary commands.

The cautionary command should be pronounced *slowly* and *distinctly*, and the executive one *decisively* and *sharply* for rapid movements; while a *slow, soft, prolonged* tone should be used for slow movements. Thus the executive command will indicate at what rate of movement an exercise is to be performed. The condition of expectancy created by the cautionary part of a command awakens the mental interest of those under instruction, and enables them to respond smartly when the executive

command is given. Thus, with the correct use of words of command, children will think quickly and respond smartly ; and, by the modulation of the teacher's voice, their movements will be regulated. The class is also thoroughly under control, strict attention is ensured, and all inaccuracies are easily adjusted, and, if the teachers are firm, clear, and concise in giving their directions, prompt and accurate performance of movements will result.

After children have practised a number of exercises in rapid succession, the teacher may give the command to rest, or "Stand at ease"; but this command need not be given often, as in the time set apart for physical training in elementary schools the children's muscles can hardly be overtaxed if arm, trunk, and leg exercises are sufficiently varied. Still, the children may be allowed to rest while the teacher explains or demonstrates a new movement.

Accuracy in detail is of the highest importance in conducting a course of physical training. The strictest attention should be paid to minute detail in all movements, whether elementary or advanced. Accuracy necessitates attention, and this implies in its turn complete subordination of the movements to the control of the will.

Attention paid to the correct execution of the most elementary movements and positions will materially lessen the difficulty of the succeeding exercises.

Tables of exercises, supposed to be suitable for certain classes, no matter how scientifically arranged, should be treated with very great caution in the physical training of school children, as such frequently tend to make the physical lesson a monotonous task to be repeated day after day, and week after week, until both teacher and pupils are wearied by the sameness of the subject.

As previously stated, teachers should be thoroughly familiar with the entire system which they are supposed to teach, and the variation of the exercises should be left to their discretion, restriction only being placed on the limit of advance. This will admit of the performance of all movements previously practised. In other words, the elder children should perform the advanced exercises in addition to the whole of the elementary and intermediate ones, at the discretion of the teacher. Therefore a course of physical training for school children should be a *progressive* one, commencing with the simplest exercises. The teachers should not be required to strictly follow the course as laid down, but should be allowed to select movements from each group to meet the requirements of their pupils. Hence the necessity of insisting that all teachers, male and female, who profess to teach physical exercises, should have at least an elementary knowledge of the anatomy and physiology of the human body. On the other hand, if tables of exercises are laid down to be performed by certain classes, and no discretion allowed on the part of the teacher, no such theoretical knowledge is necessary, as the task is set, and there must be no departure from it—consequently the teacher has no choice in the matter.

It is most desirable that the instruction in physical training to school children should be made as interesting as possible. Indeed, the interesting nature of an exercise, rather than the fear of punishment or the teacher's displeasure, should be the incentive to its proper performance. It is well-known that children are insatiable in their desire for change and variety; and although it is not suggested that a scheme of physical training should be entirely regulated by this demand, yet the latter cannot be altogether ignored. Teachers will be the

better equipped for giving instruction in the subject when the system employed provides for a judicious amount of variety. Suppose, for instance, that a certain exercise has become very familiar by reason of its regular and continued practice. In such a case, familiarity may not breed contempt, but it will bring about a lack of interest and even a feeling of dislike, and the exercise in question will suffer in the matter of execution as well as utility. A satisfactory system of physical training will provide for this inevitable contingency by the introduction of variations and additions which, while not destroying the main purpose of an exercise, will slightly increase the difficulty of its performance or change its appearance sufficiently to create a new interest in it.

The claims of a system to scientific arrangement are of little value if no attempt is made to interest those to whom that system is applied. In the end, its practical value will be much less than that of a system whose claims to scientific arrangement may appear to be weak, but whose power of interesting children may be strong. It is not necessary that two or more successive lessons should be precisely similar except under special circumstances; neither is it desirable to make considerable chauges between one lesson and the next. The plan of arranging a series of exercises in tabular form to be followed, without variation, during a number of consecutive lessons, is not educational, inasmuch as it is not progressive.

If this method as suggested is observed, a change can be brought about at every lesson, consequently it will become interesting to all. A satisfactory state of efficiency can nearly always be arrived at by such a method, besides which it promotes thorough conscientious work in all classes throughout a school, all children receiving the maximum benefit of the

training in the limited time set apart for the subject. The majority of teachers who have given this matter their careful attention have found by experience that the use of restricted tables has been extremely unsatisfactory; for in an elementary school there will be found children who are well clothed and fed, and others who are badly clothed and ill fed; consequently the physique of the scholars will vary considerably. It is thus obvious that a tabulated syllabus of exercises is not equally applicable to each pupil, as the stronger and more robust ones will not receive adequate training, should the syllabus be suitable to the weaker ones; while, on the other hand, if the syllabus be suitable to the stronger children, the exercises would prove injurious to the less robust. A teacher who is thoroughly conversant with the system adopted, if it be a good one, can obviate the danger above mentioned by carefully selecting and combining the different exercises which, by their frequent variation, will produce the desired effect. Where set tables of exercises are countenanced, a better display is frequently produced than is the case where such tables are not in use, owing to the constant repetition of the same movements; but such mere proficiency is not indicative of beneficial results, and cannot be regarded as the primary object of physical education.

In conducting the physical education of school children it is not necessary to go through a specified lesson. It is far more beneficial, in a hygienic point of view, to secure the correct execution of a small number of movements than to hurry through a large number in a careless and superficial manner. Still, arrangements should be made whereby exercises for all parts of the body are introduced during the lesson, and if the lesson is conducted in the open air, respiratory movements should always be introduced. Simplicity

of exercise and grace of movement should be the prevailing features in the physical training of school children. Nothing intricate or of an acrobatic character should be introduced; and every exercise, however simple, should be taught with the view of benefiting some particular part of the body. Great attention should always be paid to the most elementary movements and positions, as their correct execution will materially lessen the difficulty of the succeeding exercises, if the system taught is a thoroughly progressive one.

The benefits to be derived from teaching physical exercises to children will be best secured, not by the time expended on the subject, but by the frequency of the lesson; so that, as the children's minds are gradually developed, their physical powers may be simultaneously fitted to meet the demands made upon them in after life. If it could be so arranged that every class in a school should devote not less than ten minutes to physical exercises every morning and afternoon without fail, and in the open air whenever possible, a great improvement would be soon noticed in the "set-up" and bearing of the scholars. By adopting such a scheme, the instruction given would be more thorough and methodical, a more beneficial result would be apparent, while the pernicious practice of "working up" in readiness for periodical examinations, which is frequently the case, would be entirely prevented.

The great disadvantage of performing exercises in class-rooms is the want of sufficient floor space. This produces many bad results, *e.g.*, unsteadiness and slovenly habits are induced, detection of inaccurate movements is difficult, and children are liable to injury by coming in contact with the desks. It is, therefore,

absolutely essential that all exercises executed between the desks in a class-room should be of the simplest nature, and require the least amount of space for their performance. Such exercises should be selected as do not induce rapid breathing, or necessitate movements of the feet, *e.g.*, movements of the upper limbs, head and trunk chiefly should be introduced. Slapping the hands on the clothing when assuming the position of "Attention" should be strictly prohibited, as tending to circulate the dust which often contains germs of infectious diseases, which may prove most injurious to those breathing an atmosphere thus contaminated. Stamping the feet produces the same ill-effect, and when this is permitted during marching other pernicious results ensuė, (*a*) a full pace cannot be taken at each step, (*b*) the feet meet and quit the ground in an unnatural manner, (*c*) and the proper action of the knee and ankle-joints is impossible.

When it is necessary to teach physical exercises in class-rooms, the children should not on any consideration be made to stand on the seats. The fear of overbalancing will prevent the proper execution of the various movements, especially those requiring vigorous action, while serious and even fatal accidents may occur through the children falling from the seats.

To render exercise as beneficial as possible it should always be taken in the open air. If circumstances will not permit of this, the room in which the exercises take place should be freely ventilated, as a great part of the benefit derived from exercise is due to the increased circulation and more perfect oxidation of the blood. An ample supply of oxygen is therefore needful, and

this can only be obtained by allowing free ingress to the external air.

To secure the interest of children in physical exercises variety is most essential, and, next to this, entertainment; and the more closely physical exercises can be made to resemble play, so will they be likely to meet with the hearty appreciation of children.

The time selected for physical exercises should not encroach on the ordinary play-time. The lesson ought to be taken from actual school-time, and reckoned as actual school-work.

It has been proved, after the closest observation, that the time which has been taken from the ordinary hours of study and devoted to physical exercises, has been amply repaid by the increased diligence which the children evince on resuming their ordinary class-work.

Physical exercises should be performed both during the morning and afternoon, but some difference should be observed in the mode of their application. Those which demand the greatest amount of muscular energy should be taken in the forenoon, when the children's minds and bodies are in their best condition; while in the afternoon, exercises requiring the least amount of effort ought to be selected. The most appropriate time for exercise is about the middle of each session. In schools where few indoor facilities exist, and where outdoor physical training is invariably the rule, exercise in the open playground is impossible during unfavourable weather. If in such case the morning lesson be unavoidably lost, there is the probability of the weather clearing in the afternoon, so that the children may still receive one lesson during the day. In schools where only one lesson a day is given, the morn-

ing should be chosen for that purpose in preference to the afternoon, so that when the lesson cannot be imparted in the forenoon it may yet be possible to give it later in the day.

The lesson in physical exercises will prove more beneficial to the scholars if it is made to follow one during which the children have been sitting, and which has required a great amount of mental concentration. By observing this rule a period of comparative relaxation is secured for both scholars and teachers, as their minds are entirely diverted into a new channel. A few simple exercises performed during change of lessons will have a beneficial and rousing effect upon the children, especially on those inclined to be dull or sleepy.

Silent drill may be practised with great advantage, as it cultivates strict attention and observation. The teacher performs accurately and in rapid succession such exercises only as may be repeated by the pupils while their eyes are directed to the front. A few exercises thus performed are of great value when changing lessons, as a fair amount of work can be done in a very limited time, the teacher's voice is spared, while other classes are not disturbed by any words of command.

The movements selected for an ordinary lesson in physical exercises should be so arranged that every part of the body may receive due attention. The lesson should begin with a few preliminary positions and simple exercises, preferably those which will occur in the lesson to be given, correct execution being strictly insisted upon. Exercises of a more advanced nature, requiring more energy in their execution, should follow. Marching and deep breathing exercises—if the lesson be conducted in the open air—may then be introduced; after which

as the lesson draws to a close, each succeeding exercise should be of a milder form than the preceding one. The selection of the exercises will depend in great measure upon the age of the children, their previous occupation in school, the facilities for outdoor work, the condition of the weather, time of day, and the sex, constitution, and social position of the scholars. The average physique of a boy, being superior to that of a girl, demands that the exercises of the former should be performed with more vigour, and continued for longer periods than those of the latter. There is no necessity for the adoption of two systems—one devoted to each sex—in the physical training of school children. A system that may be found beneficial for one sex may be equally beneficial to the other, but this will depend chiefly on the method of application. Still, with all systems, gradual and systematic increase in the amount of physical work is necessary.

Children of very weak constitution should be excused after performing a few simple movements. In country districts, children have frequently to walk a long distance in order to reach the school. When this is the case, they should not be required to perform the more vigorous exercises for the lower limbs; and after executing the simpler movements they should be allowed to rest during the remainder of the lesson.

It will conduce to the comfort and steadiness of the class if the children's backs are turned towards the light when exercising indoors, but they may face towards the windows if the latter are provided with blinds. When a lesson is conducted in the open air, a shady part of the playground should be selected: but if this is not possible, the children should not be allowed to face towards the sun: neither should they be kept for any length of time, during hot weather,

with their backs towards the sun. It is not advisable for many reasons, to conduct physical exercises in the open air during very windy weather. In damp or cold weather, the most beneficial exercises in the playground will be those which bring the lower limbs into vigorous activity. Marching in quick and double time, hopping, and marking time will secure this object.

During physical instruction nothing should be allowed to hinder the free play of the trunk and limbs. All such appendages as satchels and scarves should be removed previously to the commencement of the lesson. The wearing of overcoats, capes, cloaks, and such garments during physical exercises should, for many reasons, be prohibited, chiefly because they produce discomfort, by obstructing free movement and causing excessive perspiration. The habit which many boys have of carrying their caps concealed about their clothing is also highly objectionable.

In mixed schools, when scholars of opposite sex are being instructed together, the girls should be placed on the left of the class, so that when the ranks are "opened out" they will be behind the boys.

It is strictly essential that methodical system of marching into a hall or playground for the drill lesson should be rigidly enforced, and the children should be taught from the earliest stage to be prompt in the formation of the class for exercise. The observance of these two points will effect a considerable saving of time, and will enable the class to receive a longer lesson than is frequently the case. The return of the children to the class-room after exercise should also be conducted in a methodical manner. FIG. 54.

A methodical assembly, before the morning and afternoon session, is highly essential as an aid to discipline and punctuality; but it is not

Fig. 54.

Lollard Street Board School, S.E.

Showing a methodical assembly of scholars in the playground. Number of boys present 325.

Area of space available 235 square yards.

advisable to select this time for a *lesson* in physical exercises, as, among other reasons, a sufficient interval will not have elapsed since the children's meals, or their active participation in various games. If physical exercises are taken at this time, or at change of studies, they should in no way be considered as a *lesson*, but merely the practising of a few, simple, familiar movements by way of relaxation. Consequently a clear distinction should be drawn between the *practising* and the *teaching* of physical exercises. A certified time should be set apart, once or twice a week, for the teaching of physical exercises to each class. During this lesson the teachers can rectify any errors noticed during the practising, correct faulty positions, and introduce fresh exercises for their pupils. This lesson may, in the case of the older scholars, be of longer duration than one which is given to younger children, but in no instance should it exceed thirty minutes.

A class of beginners should not, as a rule, consist of more than forty children. As each class becomes tolerably proficient in the performance of the exercises, the number of scholars may be indefinitely increased, until all classes may work *en masse*, providing the necessary facilities exist. FIG. 55.

Unsystematic training is apt to result in one side of the body being more developed than the other, as from habit the former is more frequently exercised than the latter; hence, in the performance of physical exercises, it is essential that the work be equally distributed over both sides of the body. Thus, should an exercise be performed by the right side of the body, it must be repeated by the left. It is

FIG. 55.

LOLLARD STREET BOARD SCHOOL, S.E.

THE CLASSES SHOWN IN FIG. 54 OPENED OUT FOR PHYSICAL EXERCISES.

immaterial whether an exercise is commenced on the right or left, provided that the same movement be repeated on the opposite side.

After exercise, children should not be allowed to rest in places where the temperature is much above or below that in which the exercises were performed. Draughts should be particularly avoided, both during and after exercise; for should the body be exposed to currents of cold air, the sudden change of temperature will suppress perspiration, thereby causing chill and perhaps muscular rheumatism. Perspiration due to exercise is the reverse of debilitating. It equalises and stimulates the circulation, relieves the internal excretory organs, improves digestion and nutrition, and invigorates the skin. Therefore exercise, to have its full effect, should be continued until a sensible degree of perspiration is experienced.

THEORETICAL SYLLABUS.

(Approved by the School Board for London.)

(i.) Physiology : General acquaintance with the build of the body and the bones of the skeleton ; special study of the spinal column, the ribs and shoulder girdle, the pelvic basin and the bones of the limbs ; the chief joints, their classification and limits of movements ; muscle and movement ; structure and function of bone and cartilage ; general acquaintance with physiological functions, with a more careful study of respiration, circulation, the abdominal organs and digestion ; the skin and its functions ; the nervous system in outline.

(ii.) Hygiene : Effects of exercise (local and general) ; rules to be observed during and after muscular exertion ; symptoms of over-exertion ; advantages of frequent short exercises ; effects of bad posture in sitting and standing, good postures—reading, writing and needlework ; general rules for conducting a lesson in physical exercises ; class-room exercises ; ventilation of rooms ; games as physical exercises.

THEORETICAL SYLLABUS.

(Approved by the British College of Physical Education.)

(i.) General structure of the skeleton and joints : effect of exercise on the muscles, heart, blood and circulation, lungs, respiration, skin, nerves and reflex action ; air and ventilation ; food, digestion and clothing in relation to physical eduehtion.

(ii.) Objects of physical education ; points to be observed in conducting a lesson in physical exercises : symptoms of overwork and fatigue ; necessity of repose : value of discipline ; use of games and systematised exercise ; positions favouring spinal curvature and other deformities ; methods of dealing with underfed and ill-developed children.

THEORETICAL EXAMINATIONS.

The following are some of the questions set at various examinations for the School Teacher's Certificate in the Theory and Practice of Physical Education, held by the London School Board, 1879—99; by the British College of Physical Education in London, Cheltenham, Exeter, Farnham, Glasgow, Hastings, Montrose, Warrington, Wolverhampton etc., 1892—1904; and those held at the following Training Colleges. Bangor, Carmarthan, Chichester, Culham, Exeter, St. John's (Battersea), St. Mark's (Chelsea), Wandsworth, Westminster, and St Mary's (Hammersmith), 1892—1904.

The above examinations varied in duration from 1½ to 3 hours, and from four to ten questions were set on each occasion. During the past four years, the number of questions set at any one examination has not exceeded eight, the time allowed being from 1½ to 2 hours.

The instructions for candidates taking the examinations have generally been as follow:—

Instructions.

You are permitted to attempt four questions only.

Write your name in full and the name of your school at the top right-hand corner of each sheet of paper.

Use a separate piece of paper for each answer, and write the number corresponding to the question before each answer, and before handing in your paper see that the answers to the questions are in their consecutive order: viz., 1, 2, 3, 4 etc.

Write on one side of the paper only, and fasten them together at the top left-hand corner.

Read each question carefully, and do not introduce irrelevant matter into the answers, which should be as concise as possible.

Sign your full name at the bottom of the last sheet of paper, and write distinctly.

What is meant by respiration, and what are its effects on the body? How and by what organs is it performed, which are the constituents of air, and what change is effected on it by respiration?

What do you understand by impure air, and what are the effects brought about by breathing such air?

Describe the structure of muscle and its action. State how the latter is brought about. Give instances of the different orders of levers that are to be met with in the human body.

How is the waste of the body made good? Is a rapid exchange of matter in the body conducive to health; and, if so, by what hygienic means can we promote this process?

What is the difference between voluntary and involuntary muscles? Describe the effects of appropriate exercise on the muscles, on respiration, circulation, digestion, and other functions.

Describe the organs of respiration and their functions. Indicate the action of the diaphragm.

In what way is the development of a child influenced by food, clothing, work, and attitude?

What order of lever does the foot represent in heel raising. The fore-arm in arm-bending. The pelvis in trunk-bending, forwards and backwards?

What is meant by physical exercises generally? What is meant by a gymnastic system?

Describe the vertebral column as a whole.

What is meant by lateral curvature?

What reason can be given for the fresh colour observed in a person's face during health? Why does a person grow pale during prolonged and severe exercise?

Why ought children who are insufficiently nourished to have less physical exercise than robust well-fed children?

Which are the injurious positions which a child may be compelled to assume in the school-room?

Why ought you not to give a gymnastic lesson to starving children?

Why ought the gymnasium (exercising-room) to be well ventilated? Why should the temperature be lower than in the school-room?

Describe the manner in which the erect position is maintained in man.

What influence does exercise exert over the muscles, the circulation of the blood, and the nervous system?

State the symptoms of excessive exercise.

What is the aim and object of educational gymnastics, and why is it desirable that they should be practised in addition to outdoor games?

Why is it so important that a room in which physical exercises are conducted should be particularly well ventilated and cool?

How should exercise be taken to be beneficial, and by what should its amount be regulated?

How would you define exercise, and in what manner does it affect the muscular system?

Give a concise list of exercises you think suitable for class of beginners.

Describe briefly the exercises that can be performed in a class-room without removing the desks.

What effects on the muscular system result from the neglect of proper exercise?

In conducting a course of physical training, state concisely some of the principal points to be observed.

What benefits, apart from those directly affecting the muscular system, result from properly directed healthy exercise?

In what "positions" should purely respiratory exercises be conducted, and how should they be executed?

What are the effects of proper respiratory exercises?

What, in your opinion, is the proper duration of a gymnastic lesson for children in elementary schools, and what the most suitable time in the day for conducting it? Give your reason for such opinion.

Give a definition of the term and explain the objects of "Physical Education."

Explain shortly why children who are not well

nourished should have less physical exercise than those who are properly fed.

Explain why it is considered better to exercise children attending elementary schools in free movements rather than on apparatus, and mention the principal points to be observed in conducting a lesson in physical exercises.

State which you consider are the better exercises for a person who is overworked mentally; those demanding skill, or those of an automatic character; and give your reasons.

Explain why a period of repose is necessary after hard physical exertion, and what evil consequences would result if it were not taken.

What is the cause of the healthy glow upon a person's face during proper and moderate exercise; and how do you account for the pallor observable after prolonged or undue exertion, and of what is this latter indicative?

What are the effects of respiratory exercises, and at what period of a lesson in physical drill should they be performed?

Why is it imperative that in a room in which physical exercises are performed the air should be cool and pure and the ventilation as perfect as possible, and what should be the temperature of the room?

By what should the amount of exercise taken by an individual be regulated, and what are the symptoms of over-exertion?

How is the skin affected by exercise; what are its functions; and why is it so important that it should be kept clean?

State briefly the effect upon the muscular system of the want of proper exercise, and explain why repose is necessary after hard bodily labour.

State briefly the results we seek to obtain by a course of systematized physical exercise, and upon what does the benefit therefrom chiefly depend?

State why it is desirable that gymnastics should be practised in addition to outdoor games, and also what is the proper duration of a gymnastic lesson for children in

elementary schools, and the most suitable time in the day for conducting it.

About what should be the temperature of a room in which a lesson in physical exercises is given, and what effects on the atmosphere are produced by a number of persons being exercised therein, and about what cubic space should be allowed for each pupil?

State some of the dangers to be guarded against when conducting a lesson in physical drill, and how should persons be clothed while taking hard exercise?

Explain why it is injurious to children to give them a drill-lesson shortly after a meal, and what is the most suitable time in the day for such a lesson?

In order that physical exercise should be beneficial, mention some of the essential conditions under which it must be conducted, and if these conditions are violated what evils will inevitably result?

In order to put in action the voluntary muscles, is any stimulus required? If so what is its nature, whence is it derived, and by what medium is it transmitted to the muscles?

Explain why a period of repose is necessary after physical exertion, and what is the most perfect form of rest.

Enumerate some of the principal objections to the use of the gymnastic apparatus in elementary schools, and also give your opinion as to the desirability of allowing children to sing while performing physical exercises, and state briefly the grounds upon which such opinion is based.

What is the proper position that a person should assume when writing at the desk? Mention some of the injurious positions into which children frequently fall while at lessons both while standing and while sitting?

State which you consider are the better exercises for a person who is overworked mentally; those demanding skill or those of an automatic character; and give your reasons.

What is meant by the term *system* of physical exercises? State concisely the advantages of a system in a school. What are the essentials of a good system?

To what extent are games valuable as a means of physical culture? Show the necessity for their proper supervision.

Distinguish between *local* and *general* muscular movements. Which are the more important in the physical training of children, and why?

What do you understand by lateral spinal curvature, and what conditions of school life might have a tendency to induce it? How may the tendency in the early stages be counteracted?

Show the importance of a proper supply of fresh air to physical well-being, and point out the bearing of this consideration (*a*) on school life generally; (*b*) with special reference to physical exercises.

What is the proper position for a child (*a*) when standing to read; (*b*) when writing? Give reasons.

State the advantages of frequent short exercises in drill. When is the best time for stated lessons in drill, and why is it advisable to have them in addition to the short practice lessons?

What rules should guide you in conducting a class of children in drill? What are the usual signs of over-exertion?

Name the two great divisions into which the voluntary muscles are divided. Which of these should more particularly be exercised, and why?

Why should not young children be exercised on fixed apparatus? To what extent and at what age would you permit the use of light movable apparatus?

State briefly how the lungs may be exercised: (*a*) directly; (*b*) indirectly. Why is it important that air should generally be inspired through the nostrils?

State concisely the advantages of frequent short exercises. What is the purpose of the longer lesson in physical exercises? When should this be taken?

Why is it necessary to have intervals of repose during a long drill lesson? Mention some of the visible signs of over-exertion.

What injurious results follow from seating children in unsuitable desks? What faulty positions do children assume when at needlework, and how would you correct them?

State the points which require attention in the posture of the child, when occupying a dual desk, during ordinary lessons.

Give some account of the structure and growth of bone and cartilage. What is understood by the ossification of cartilage?

Describe the general structure of the kidneys and state briefly the nature of the work performed by these organs. Should the kidneys fail to act what changes take place in the blood?

How is ordinary respiration brought about? How much air is given out and taken in during ordinary respiration?

Distinguish between the forward and backward position in sitting. What parts of the skeleton serve as points of support? What further supports become necessary to children seated in desks?

Describe the construction of the shoulder girdle, and explain how exercising the arms and shoulders affects respiration.

What variations would you make in your drill lessons (*a*) in very warm weather; (*b*) in very cold weather? Explain why.

Point out in the Physical Exercise course you have studied how the exercises are *systematic*, and not independent one of another.

What parts of the skeleton are respectively termed "clavicle," "patella," "radius," "scapula"? With what other bone is each connected and how is the connexion effected?

What causes the blood to flow constantly in one direction? Under what circumstances might the blood current be (*a*) slower through the body; (*b*) restricted in any particular organ?

What is meant by digestion, absorption, and assimilation of food? Are these processes influenced by muscular exercise? If so, state when the influence would be beneficial and when injurious.

Explain in detail how the exercise of a few muscles can affect the circulation of blood throughout the whole body,

and in what way excessive exercise hinders circulation.

What is involved in "a good carriage"? How does physical exercise develop "a good carriage"? What point would you first attend to in endeavouring to improve the bearing of a slovenly class?

What hours of the school day are least suited from a physiological point of view for physical exercises, and why?

Explain fully how moderate exercise influences the functions of (*a*) the liver, (*b*) the stomach.

What is "perspiration," and how is it produced? What is meant by "sensible" and "insensible" perspiration? When is perspiration a healthy symptom, and why?

How would you tell an artery from a vein in a dead animal? What are the chief differences between arteries and veins, and what purposes are served by the arteries being so different from the veins?

Show the importance of "style" in the teacher of physical exercises, including under this, tone of voice, delivery of command, smartness of his own movements.

BRITISH COLLEGE OF PHYSICAL EDUCATION

What effects has systematic exercise on the nervous system?

Why is it important that a gymnasium (exercising room) should be well ventilated?

What is the value of flannel as an article of clothing? Is it more important to change before or after exercise?

Give a brief description of the circulatory system in man.

What are the relative merits of indoor and outdoor exercises?

What are the best times of day to take (*a*) food, (*b*) exercise?

What is the difference between air inspired and air expired?

What is the effect of muscular exercises on the respiratory system?

Describe the backbone and its movements. What are the uses of the curves in the spinal column?

How is the erect position maintained in man? What are the symptoms of muscular fatigue?

What is the difference between venous and arterial blood? What are the effects of muscular exercise on the blood and circulation?

What are the functions of the skin, and why is it necessary to maintain their activity? How may this be done?

What is a joint? Enumerate the component parts of a movable joint.

During repose after fatigue what physiological changes take place?

What general conditions in children favour the occurrence of lateral curvature of the spine?

How are bones joined together? Explain the structure of a joint.

Define the term and explain the objects of physical education.

What effect has exercise upon heart and circulation?

Describe the symptoms of overwork and fatigue.

Explain why it is considered better to exercise children attending elementary schools in free movements rather than on fixed apparatus.

What important uses does the blood subserve?

What points has the teacher to keep in view in conducting physical exercises?

Name the special internal organs affected by gymnastics.

In young children, how may games be conducted to aid physical and mental growth?

Give a brief description of the structure of the spinal column.

Why is discipline of great importance in managing exercises in a class of young persons?

What are the relative advantages and disadvantages of systematised exercise and games?

State why physical exercises should be made attractive, and give the various means by which you would make them so.

How does physical exercise affect the skin and its functions?

Why should work and rest alternate? What are the signs of muscular overwork and over-rest respectively?

Give a brief description of the structure of muscular fibre.

Enumerate the several varieties of joints. Give examples.

What effect has an undue amount of exercise upon the internal organs?

What advantages has physical education in elementary schools?

Give your reason for selecting any particular class of pupil for (*a*) exercises in games, (*b*) systematised drill.

Explain concisely the movements of respiration and the phenomenon of breathlessness.

Point out in detail the effects of dress on the body during active physical exercise.

Discuss the advantages and disadvantages of musical calisthenics.

State the reasons why physical exercises are of special benefit to girls.

Give a brief description of the structure of the skeleton.

What are the effects of muscular exercises upon the skin and its secretions?

Give the composition of pure and impure air, and state its importance as to ventilation.

State the value of swimming in physical education, and the dangers of excess.

What methods would you adopt when dealing with underfed and ill-developed children as regards physical education?

What are the effects of systematic physical exercises on the nervous system? Can you influence a child's character by these means?

What are the earliest symptoms of fatigue?

What precautions in respect of clothing are to be taken during and after physical exercise?

Name the objects you have in view in physical education. How may you popularize physical exercises?

What uses do games subserve in elementary schools?

What is a voluntary muscle? Mention the parts of a long muscle as viewed with the naked eye.

Gymnastics are an important part of education. Why is this? and why are out-door games a necessary accessory?

What exercises are beneficial in poorly-developed children?

What is the general structure of bone?

What exercises without strict supervision conduce to one-sided development of the body, and how may this tendency be counteracted?

Describe the movements of the heart, and the effects produced by physical education upon respiration and circulation.

Explain how gymnastics are conducive to growth.

What positions in school are most detrimental to perfect development, and how may these be combated?

What sanitary rules and precautions would you think

it necessary to issue to ensure hygiene amongst your pupils?

Describe the clothing most fitted to physical exercise amongst boys.

Describe the shoulder-joint and the movements of which it is capable.

How does exercise affect the venous circulation?

What relation has dress to respiration?

Briefly enumerate the respective advantages of games and gymnastics.

Are calisthenics beneficial to the nervous system, and why?

What structures enter into the formation of the knee-joints, and of what movements is it capable?

In what forms of exercise is the heart often overtaxed?

How may you prevent by calisthenics the usual deformities in growing girls?

Why is the question of clothing important in systematized exercises?

Explain the beneficial advantages of outdoor games.

What is the effect of exercise on the venous circulation?

What are the advantages and drawbacks of music in drill?

Show and prove the importance of dress in physical exercises for girls.

What are the "weak points" to be looked for in examining the fitness of children for physical exercises?

Give a brief description of the bones constituting the thorax.

What are the effects of lunging with arm movements on respiration?

Describe accurately how exercise specially aids the circulation.

What exercises most develop the brain?

What is "bad air?" How is it produced and how is it removed?

Describe the liver and its use.

What are the chief points that distinguish a "good" from a "bad" attitude

What is the effect of over exertion?

How does the blood circulate through the heart?

Describe the foot and how it is affected by exercise.

Describe the elbow joint and the movements which take place at it.

Describe how ordinary respiration is performed and how it affects the condition of the blood?

Name the different kinds of nerves in the body, and explain briefly the functions of each class.

Describe the structure of muscle and state what effect exercise has upon it.

Describe the general structure of a joint.

Describe the effects of exercise upon the skin and the requirements of clothing in relation thereto.

Classify food in relation to physical education.

Name the long bones of the body and the joints connected with them.

What muscles are concerned with, and developed by (*a*) balance movements, (*b*) trunk movements?

What value do you attach to balance movements?

In the case of very young persons how may games be conducted to aid physical and mental growth?

What positions may give rise to spinal curvature with drooping of the shoulders?

Compare and contrast the joints in upper and lower extremities (arm and leg).

What exercises best develop the muscles of the abdomen?

Name some physical ailments that would be made better by physical exercises, and some that would be made worse.

What foods are best for violent or hard work, and how much is required daily?

Name some simple physical deformities and state how they can be removed by exercise.

What bones form the thorax and how do they move?

What circumstances during exercise might lead to fainting?

Describe the movements which can be effected by the head and spinal column, stating exactly when and how they take place.

Explain how the equilibrium of the body is maintained.

What value do you place upon repose following exercises?

What are the effects of deep breathing? Explain why respiration should be carried on through the nostrils.

How are the skin and kidneys related in their functions?

Describe carefully the proper position of the body when standing.

What bones do we stand on, and what muscles do we stand with?

What bones form the back and how are they arranged?

What effect would deficient food have upon those who sustain vigorous exercises?

Explain what are the various requirements necessary to keep the skin in a hygienic condition.

Explain why proper development of the whole muscular system of the body is important.

What abnormal conditions does school life tend to produce in children?

What precautions do you advise in the taking of baths after exercise?

Describe the structure of voluntary muscle. Explain how contraction of such a muscle takes place.

What effects does respiration produce on the air of a room? What means should be taken to keep the air of a room in which there are human beings normal?

Describe the kind of instruction in Physical Exercises most suitable for young children up to the age of 12 or 13 years, and give your reasons for your statements.

What are the uses of the liver? Describe its blood vessels.

When is air in a room unfit to breathe? How do you improve it?

Describe and explain how voluntary movements are effected.

How is animal heat produced and maintained in the living body?

Describe the signs of fatigue, and how would you prevent fatigue in young persons (under 16 years of age) employed in games?

TRAINING COLLEGES.

Describe some of the good effects of physical recreation on children.—(*a*) Physical, (*b*) moral.

Why should the young undergo systematized exercise in addition to playing athletic games?

What do you consider should be the duration of a lesson in physical exercises for children between the ages of ten and fifteen, and how many lessons a week should suffice?

About what temperature should the atmosphere of a room be during a lesson in physical exercises? How should those being exercised be clothed?

State some of the dangers to be guarded against in conducting a lesson.

Describe briefly the symptoms of exhaustion and over-fatigue.

What is the aim of educational gymnastics? Why should they be practised in addition to outdoor games?

Mention some of the principal points to be observed in conducting a lesson in physical exercises.

What should be the duration (about) of a lesson in physical exercises for children between the ages of six and fourteen, and what the best time of the day for conducting it?

State why it is injurious to take violent exercise shortly after a meal.

In teaching physical exercises to school children, which is most desirable, a local or general effect? Give your reasons.

Name some of the injurious positions that children frequently assume when at lessons, and explain how these may be obviated.

What is the most suitable period, during the ordinary school hours, to conduct a lesson in physical exercises, and why are foot movements objectionable when conducting exercises in class-rooms?

What value are respiratory movements? During what period of the usual lesson should they be practised, and where?

What benefits are derived from teaching systematic physical exercises to school children in preference to military drill only?

Explain why a period of repose is necessary after hard physical exertion, and what evil consequences would result if it were not taken.

Describe the spinal column, the movements that are permitted in the same, and the locality in which they chiefly occur.

By what should the intensity and duration of a lesson in physical exercises be regulated; and why should movements of the feet be performed as little as possible when conducting a lesson indoors?

Explain why *favourite* games only are unsuitable as physical training for school children.

What is the use of clothing? What rules as to clothing should be observed when teaching physical exercises to school children?

Which arrangement among the following do you consider best for the heating of school-rooms, hot-air pipes, open fire-places, or closed stoves? Give your reasons.

The natural movements of the body are of two kinds. Name these and explain them respectively. What is *muscular sense?*

Why is the attitude of "attention" difficult to maintain for any length of time? Why is it more difficult to stand on one foot than on both?

What are the essentials of perfect ventilation in a school-room? What cubic space should each child have, and what is the most agreeable temperature?

What is the difference between inspired and expired air? Explain why it is better to breathe through the nose than through the mouth.

What changes does the blood undergo in the capillaries of the lungs and of a muscle?

What movements can be performed by the hip-joint, and in what way do they differ from those of the shoulder-joint?

What are the relative merits of games and systematic movements in the physical training of school children?

What are the moral effects of recreative games?

What is the value of music when applied to physical exercises? Should exercises be always accompanied by music? Give your reasons for or against.

What moveable apparatus (such as clubs, dumb-bells, wands etc.) are most suitable for the use of children in elementary schools?

Why are movements with apparatus (such as clubs, dumb-bells, wands etc.) more beneficial in a physical sense than movements performed without any apparatus?

Why should movements of the lower limbs be excluded from a syllabus of class-room exercises? Explain why foot stamping and marching should be discouraged in class-rooms.

State briefly the advantages of discipline during a lesson in physical exercises.

Which is the most desirable course to adopt with school children, *frequency* or *duration*, as regards the teaching of physical exercises?

Should children be permitted to count the time audibly when performing physical exercises in the open air? If so, what are the benefits accruing from such a practice?

When is it necessary to teach physical exercises in class-rooms? What are the disadvantages of performing exercises in class-rooms? Give rules for conducting a lesson under such circumstances.

Explain the difference between a *practising* and a *teaching* lesson in physical exercises. What time should be devoted to each in order to secure the best results?

What is the primary object of physical exercises in schools? To what extent are they an aid in the maintenance of school discipline?

Are restricted tables of exercises advisable in the physical training of school children? Give your reasons for or against.

State the order of progression to be observed in passing from the most elementary movements to the use of light movable apparatus as dumb-bells and wands. At what stage would you advocate the use of music?

What organs are contained in the cavity of the thorax? What is the principal office of the thorax, and what parts enclose the cavity?

Describe the different varieties of joints, and give an example of each?

What value do you attach to military evolutions as a means of training for the young, either in a moral or physical sense?

What is the best time of day for a physical drill lesson in an elementary school, and where should the lesson be given? Give reasons.

What organs are contained in the thorax? Describe briefly the functions of each.

What is the value of exercises being systematic? What benefit accrues from one exercise being dependent on the correct execution of another?

Describe the structure of the knee, and compare it with the elbow joint, give the names of the bones thus joined, and state the kind of movement which takes place at these joints.

What is the most prevalent form of spinal curvature to be found among school children? To what is it generally attributed, and what means are in the power of a teacher to counteract this defect in its earliest stages?

What are the disadvantages of performing exercises in class-rooms? What rules would you observe in the selection and teaching of exercises, if compelled to give the lesson in a class-room?

In dealing with an advanced class of pupils, how would you proceed in order to make the lesson interesting without detracting from its beneficial effects?

What are the advantages of exercises such as free, dumb-bell, or wand, as compared with work on apparatus such as a horizontal bar, parallel bars, etc.?

What is the object in teaching respiratory movements? State how and where you would teach them to (*a*) a class of beginners, (*b*) an advanced class.

In what way may systematic games be especially beneficial as physical exercises? Would it be advisable to substitute games for systematic drill and Physical Exercises?

Show the importance of good "form" on the part of the teacher of Physical Exercises, including such points as tone of voice, delivery of word of command, and precision and accuracy of movement.

At what period in a child's school-life would you introduce such apparatus as dumb-bells, wands, etc., as an auxiliary to free movements? Give reasons.

Give a brief description of a muscle, and explain how the blood flow is accelerated by muscular action?

How many bones are there in the upper and lower limbs respectively, and what examples of joints are furnished in both?

Imagine yourself to be making a School Time Table. What provision would you make for "Physical Exercises"? Give your reasons.

Distinguish between those exercises which are suitable and unsuitable for use when it is too wet to drill in the playground.

In what respects do the hip and shoulder-joints resemble each other? How do they differ?

If directed to undertake the physical training of a class of school children who lack vigour and energy, how would you proceed?

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